

Minutes of the 54th Meeting of the CEOS Working Group on Calibration and Validation

Chaired by ESA
Sioux Falls, South Dakota, USA

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Day 1: Wednesday 16th October, 2024

2.1 - Welcome and Overview of Agenda

Philippe Goryl (ESA, WGCV Chair) reported:

- Philippe Goryl welcomed all to the WGCV-54 meeting and thanked USGS for hosting WGCV, and the WGCV and WGISS secretariats for developing the meeting agendas.
- Philippe reviewed the agenda for the two WGCV days, Wednesday 16th and Thursday 17th October.
- Meeting participants made a round of introductions with a tour de table.

2.2 - WGCV-53 Action Review

Harvey Jones (WGCV Secretariat) reported [\[Doc\]](#):

- The open actions from WGCV-53 (5-8 March 2024) were reviewed.
- WGCV-53-ACT-01: *In support of the SITSat Task Team’s communication strategy, WGCV members are asked to help gather examples/case studies regarding ‘real world’ impacts of the reduction in uncertainties that are facilitated by SITSats.*
 - o This action was revisited in the last SITSat Task Team teleconference, and was decided to be kept open and discussed at the group’s side meeting on Friday 18th October.
 - o Medhavy Thankappan (GA) asked if the action sought to demonstrate how success stories can help.
 - o Nigel Fox (NPL) explained that calibration is important, but the driver is the improved accuracy that one is aiming to achieve. Even though the missions aren’t on-orbit yet, what would this higher accuracy mean?
 - o Medhavy wanted to understand what the real world examples would be.
 - o If we can’t find any ‘real world examples’ of uncertainty reductions, the argument for higher accuracy doesn’t exist.
 - o Philippe Goryl (ESA, WGCV Chair) noted that Nigel submitted a presentation for Living Planet Symposium (LPS) in June asking the same question, and that the session has been accepted. Abstract submission for the session is open.
 - o Peter Strobl (EC-JRC) suggested updating the action to mention LPS.

WGCV-54-01	In support of the SITSat Task Team’s communication strategy, WGCV members are asked to help gather examples/case studies regarding ‘real world’ impacts of the reduction in uncertainties that are facilitated by SITSats.	June 2025
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WGCV-54-03	<p>We seek to show the unique value of these types of missions and highlight differences between usual calibration practices and those provided by SITSats. Examples should be accompanied by clear, transparent metrics (financial, improved decision-making, etc.).</p> <p>These examples will be presented at a dedicated session at the Living Planet Symposium in June 2025.</p>	
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- *WGCV-53-ACT-02: CEOS SEO to explore with the SITSat Task Team the application of the CEOS Visualization Environment (COVE) tool for visualisation of SITSat orbits and acquisition plans.*
 - o Nigel noted that this action is complete. The use of COVE and next steps was discussed on Friday in the dedicated SITSat side meeting.
- *WGCV-54-ACT-05: WGCV Chair and TMSG Chair to raise the idea of creating / testing a global coastal elevation dataset / method with the leads of the CEOS Coastal Observations Applications Services and Tools (COAST) Ad Hoc Team (likely soon to be Virtual Constellation) and also assess interest from other CEOS members (e.g., GA / Digital Earth Australia/Africa Coastlines is highly applicable).*
 - o Peter Strobl noted that the COAST Virtual Constellation (VC) has been created, and that in Sydney (SIT-TW), the requirement to define a common zone was discussed. A CEOS-wide harmonised agreement on the definition of geographical coastal areas is required and is important.
 - o Peter has been working on DEMIX (Digital Elevation Model Inter-comparison eXercise) for low elevations, which is useful for COAST-VC. He will discuss with COAST-VC alongside the subject of the previous action.

WGCV-54-03	Peter Strobl to connect with the COAST-VC leads to explore the application of DEMIX for low elevations, as well as the idea of creating/testing a global coastal elevation dataset/method.	WGCV-55
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- *WGCV-53-ACT-07: Dave Borges (CEOS SEO) and Santhi Sree (ISRO) explore the inclusion of ResourceSat-2 and RISAT-1A data in the CEOS Analytics Lab (CAL), with particular reference to the interoperability study. Dave will also share the details of the Planet data available in the CEOS Analytics Lab.*
 - o Harvey noted that a discussion between Dave Borges and Santhi Sree is still in progress. Harvey will follow up on the email thread.
- *WGCV-53-ACT-09: MSSG Chair and WGCV Chair to coordinate a discussion in MSSG on the relevance of the FRM concept and explore the potential for a contribution to the Assessment Framework activities.*

- Xiaolong Dong (NSSC) noted that he will progress this action and communicate updates with the group. The action was suggested to be kept open until the next WGCV meeting in July 2025.

WGCV-54-04	MSSG Chair and WGCV Chair to coordinate a discussion in MSSG on the relevance of the FRM concept and explore the potential for a contribution to the Assessment Framework activities.	WGCV-55
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- WGCV-ACT-12: *Dave Borges to connect the CEOS Communications Team with Nigel Fox to investigate opportunities and develop strategies for better promotion and communication of IVOS achievements, recommendations (e.g., solar spectrum), news, events, etc.*
 - Nigel discussed this action at IVOS-36 annual meeting in September, noting that it would be timely to highlight RadCalNet’s success and progress towards TIRCalNet.
 - Philippe noted that we have established a connection with SEO now, and should use it to explore how we can use SEO and CAL for WGCV’s benefit. RadCalNet is a good example.
 - Nigel and Philippe suggested retaining a background action to progress this collaboration.
- WGCV-53-ACT-13: *Paolo and Nigel to make updates to the FRM Assessment Framework documentation to:*
 - *Make clear that the assessment is relative to the intended purpose of the site.*
 - *Remove subjectivity in parameters by incorporating clarifications present in the accompanying documentation, but which have to date been left out of the Matrix description.*
 - *Clarify that verification should be undertaken by independent people from CEOS, not the person filling in the template (i.e., self-assessment followed by independent review).*
 - *Make the Validation column a different colour.*
 - *Consider inclusion of additional links to reference materials, mechanisms to allow assessors to provide feedback, etc.*
 - Paolo Castracane (ESA) reported good progress on this action, which needs finalisation. The dedicated session on the Fiducial Reference Measurement (FRM) Assessment Framework on Thursday addressed the action’s progress in more detail.
 - The action should be finalised by the end of the year.
- WGCV-53-ACT-14: *Paolo, Nigel and Kuze-san, to work with Jean-Christopher Lambert on the issues with the FRM Assessment Framework specifically for the atmospheric domain.*
 - This action goes hand-in-hand with Action-13. There have been a number of iterations made, and is also close to finalisation.

- Jean-Christopher Lambert (IASB-BIRA) noted that the NDACC steering committee meeting will be in mid-November this year, and that he will share the outcomes with the NDACC instrument Working Groups (WGs) for information and feedback.

WGCV-54-05	<p>Paolo and Nigel to make updates to the FRM Assessment Framework documentation to:</p> <ul style="list-style-type: none"> ● Make clear that the assessment is relative to the intended purpose of the site. ● Remove subjectivity in parameters by incorporating clarifications present in the accompanying documentation, but which have to date been left out of the Matrix description. ● Clarify that verification should be undertaken by independent people from CEOS, not the person filling in the template (i.e., self-assessment followed by independent review). ● Make the Validation column a different colour. ● Consider inclusion of additional links to reference materials, mechanisms to allow assessors to provide feedback, etc. 	Q4 2024
WGCV-54-06	<p>Paolo, Nigel and Kuze-san, to work with Jean-Christopher Lambert on the issues with the FRM Assessment Framework specific to the atmospheric domain.</p>	Q4 2024

- **WGCV-53-ACT-19: Albrecht von Barga** to make a connection between the WGCV Chair and GSRN Task Team Chair, Tilman Holfelder (DWD), to discuss coordination of the CEOS and GSRN FRM efforts.
 - The connection has been made, but it requires more effort. Cody Anderson (USGS, WGCV Vice Chair) and Philippe will discuss this. A good discussion was held in the recent metrology meeting in Paris, with more requests to extend FRM to *in situ* measurements. *In situ* providers are looking to improve the quality of their measurements. This extends a bit outside of the validation of satellite data, but it's still important. The discussion could be transformed into something more concrete.
 - Cody asked if this action is to investigate how to use satellite networks for validation, or different FRM paths?
 - Nigel noted that specifically in GCOS, there is a requirement to harmonise WMO's TIR network to the FRM labelling. We've been trying to call things 'CEOS-FRM', but we may end up with FRM as a generic term. We have in the FRM a criteria for 'suitable for use for satellites', so the definition should be generalised more to include *in situ* data.
 - Peter noted that ARD (Analysis Ready Data) is a branding for a class of products, and FRM is too. It should be defined relatively vigorously as it demonstrates value.

- Cody explained that the desire with GCOS is to either define a new FRM or work with them to agree on a new definition.
- Nigel suggested we agree on the FRM label and assessment framework. Categories may differ, but we should generalise it and keep the specialist element. WMO seems willing to do this, and the bottom line is to draft a joint paper to make this visible.
- Peter suggested that we, without committing too much, say we're ready to contribute to the general definition that we could send to everyone. This keeps us in the driving seat and is the same approach as we have done for ARD.
- Cody asked if anyone else was involved other than CEOS and WMO. Peter noted that we expected others to come.
- All agreed to work alongside WMO.
- Nigel noted that high quality *in situ* measurements make this worthwhile, plus WMO is a member of CEOS. We don't want to go down the ISO route.
- Peter suggested we keep definitions inclusive. Eventually someone else will want to join, so we should phrase it non-patronisingly.
- Philippe suggested inviting WMO to the next WGCV meeting to present and discuss on this topic.

2.3 - WGCV Vice Chair Confirmation

Medhavy Thankappan (GA) reported [[slides](#)]:

- Geoscience Australia (GA) has increased in staff numbers alongside changes within the space division, as well as at the executive level with the CEO's foreshadowed retirement.
- There are various funding opportunities within GA, with massive programmes on resources and the space side. GA's support presents a potential transformation area for the agency.
- GA's 2028 strategy seeks to achieve 10 cm positioning across Australia and 3-5 cm in areas of mobile coverage, an EO platform for government and businesses, and streamlined access to satellite data.
- GA's Digital Earth Australia (DEA) branch provides products from satellites from land imaging collections, and does some Cal/Val and surface reflectance validation work as well. The DEA platform supports 2600 registered users.
- Medhavy belongs to the Satellite Land Imaging Collection branch. Landsat mission support is provided by the Alice Springs ground station which hosts Cal/Val infrastructure.
- Medhavy's key achievements and experience were listed:
 - Associated with EO from space for ~ 35 years
 - Experience in EO Cal / Val straddling optical and microwave domains
 - Utilisation of EO data for applications across terrestrial and marine environments

- Scientific publications in several remote sensing journals (citations 1093, h-index 17, i10-index 27)
- Current role: Director, Data Processing, Quality and Integrity at Geoscience Australia, based in Canberra
- Represented GA at CEOS-WGCV since the 2012 plenary in Brisbane
- GA’s Landsat Next partnership is backed by significant government funding until the 2034-5 Fiscal Year.
- GA supports continued free data collection programmes for Cal/Val, and support for WGCV and LSI-VC.
- Motivations for Medhavy’s Vice Chair nomination included:
 - Long history and strong track record of EO calibration and validation in Australia and active contributions through CEOS entities
 - Australia is reliant on space data providers for its national EO data needs
 - Step-up Australian contribution in support of coordinated global effort on cal / val
 - Increasing recognition of the importance of cal / val for increasing trust in EO data
 - Engagement on standards and methods for interoperability between different data sources, improves trust and reduces risk to data access from individual sources
 - Aligned with the Australian Government strategic framework for international space engagement activities
- Medhavy has interests in advancing multi sensor and platform interoperability, ARD and securing commercial sector buy-in, SITSat coordination and information sharing, and Cal/Val networks participation and contribution.
- There were no objections to Medhavy’s nomination confirmation. The room congratulated Medhavy’s endorsement.
- Cody Anderson (USGS, WGCV Vice Chair) expressed excitement that the Australian government is in support and looked forward to the next few years.

Decision 01

WGCV endorsed the nomination of Medhavy Thankappan of Geoscience Australia as Vice Chair of the WGCV for two years (2025-2026), followed by WGCV Chair for two years (2027-2028).

2.4 - Preflight Calibration Workshop Update

Nigel Fox (NPL) reported [\[slides\]](#):

- Nigel updated on the progress of the Pre-flight Calibration and Characterisation workshop. The [website](#) for the workshop was shared. Registration is still open for attendees only.
- The workshop covers passive optical sensors focused on the solar reflective domain, within the sub-2.5 micron range. There will be a day dedicated to thermal infrared (TIR) on the final day of the workshop.
- The workshop concerns the preflight characterisation of onboard calibration systems, and will not discuss geometric calibration but be limited to stray light, linearity, gain, ect.
- The intended audience are engineers, science PIs, managers/funders, and the public sector, with the aim for them to provide feedback on what is possible and necessary.
- Each session will hold a limited set of presentations under a common theme, with a discussion at the end to come up with consensus views of optimum methodologies. Three days of the workshop will be dedicated to the solar reflective spectrum, and the fourth for TIR.
- The outcome of the workshop should be citable guidance on good practices.
- The workshop's planning is divided amongst the Organising and Scientific Committees. The Organising Committee are CEOS/GSICS members in charge of the overall oversight of the workshop, and the Scientific Committee are domain experts that assisted with reviewing abstract submissions and will aid the writing of meeting conclusions and good practices documentation.
- We want space agencies and the Scientific Committee to encourage the participation of organisations that they are funding, and people that recognise the constraints due to proprietary information.
- The majority of the committees fed into the abstract review process, which assessed 60 abstracts submitted for oral presentation. The workshop is led by Nigel Fox and Xiaoxong Xiong.
- The preliminary programme has been published on the website. 60 abstracts were submitted with 23 confirmed for oral presentation and the rest as poster presentations. There are 160 registered attendees.
- The programme is organised into 30 minute oral sessions, 3 minute poster presentations, and 90 minute discussions.
- The final session on Thursday will be dedicated to discussion and report assignments.

Discussion

- Cody Anderson (USGS, WGCV Chair) will be WGCV Chair at the time of the workshop, and won't attend in person.
- Xiaoxong (Jack) Xiong and Nigel Fox will give a welcome talk with support from an ESA representative.
- Philippe Goryl (ESA, WGCV Chair) offered to welcome the workshop as the outgoing chair. All agreed.

2.5 - SRIX4Veg

Valentina Boccia (ESA) reported [\[slides\]](#):

- Valentina presented an update on the SRIX4Veg & SR Validation Protocol with UAVs also on behalf of Cindy Ong (CSIRO) and the SRIX4Veg-I and -II teams.
- SRIX4Veg Began with FRM4Veg, an ESA funded project to explore biophysical variables measured by satellites. Fiducial Reference Measurements (FRMs) have documented SI traceability, are independent from retrieval processes, accompanied by uncertainty budgets, adhere to community-agreed protocols and management practices, and are accessible to other researchers.
- Historically, surface reflectance (SR) validation measurements have been done in the field, which has limitations that can be overcome by UAVs. SRIX4Veg used handheld and UAV-mounted instruments that overcame a number of challenges. The use of UAVs is expected to grow in the future as instruments become lighter and cheaper.
- Vegetation presents challenges and opportunities to understand the best protocols and procedures to catch the dynamics of vegetation. There are several biophysical satellite products that are derived using surface reflectance over vegetation.
- No protocols currently exist for SR validation using UAVs, so a strategy was devised to initiate the draft protocol.
- There were two experiments performed: SR validation data was collected following a pre-defined protocol, and SR validation data was collected as the participants would do if given pre-defined information.
- Information was given to participants about a mock satellite (EnMAP) overpass, as well as for flight scheduling to ensure comparability. 57 flights were performed for SRIX4Veg-I, which took an entire week of back to back flights. GPS data for a fixed location was provided for all participants along with the DEM for consistency.
- ASD measurements were taken before and after each flight to allow averages and redundancy to be taken.
- Each team was asked to do data analysis and share their results with the SRIX4Veg team. A comparison assessed the impact of user decisions on the creation of SR validation datasets from UAVs, and to determine if a common protocol improves consistency between users.
- A post-campaign workshop was held at ESA ESRIN in November 2023, which is the same time that protocol shaping began. A lot of work has gone into the protocol, which has been submitted for WGCV review. Feedback from LPV and IVOS has been collected.
- The protocol was designed for SR validation datasets with UAVs, not for general SR. The document is structured into a condensed version in Chapter 5. Recommendations are based on feedback from

SRIX4Veg-I and -II campaigns and workshops. It intends to be sensor agnostic and adaptable for future scientific improvements.

- The main feedback from WGCV was:
 - o Grouping of recommendations by category (multiple)
 - o Example of uncertainty budget (IVOS) and how to assess/reduce it (USGS)
 - o Comment on straylight characterisation of imagers (IVOS)
 - o Include more information on geo-correction (USGS)
 - o More real-world examples (USGS)
 - o Recommendations on UAV flight timing (LPV)
 - o Prioritisation of recommendations (LPV)
 - o Convert some recommendations to requirements when required to achieve CEOS-FRM (IVOS)
 - o Explanation of spectral data format recommendation (USGS)
 - o More emphasis on trade-offs and regulation issues (USGS)
- All feedback is being ingested into the protocol, and changes will be made by 11 November 2024 and circulated.
- The post field work workshop on 9 September 2024 had 25+ attendees at the advancing EO forum. Intercomparison exercise participants reported on progress, future work and research areas.

Discussion

- Nigel Fox (NPL) commented that there was an action dependent on the review of this document, and proposed that we endorse the protocol subject to the modifications, in order to close the action. The modifications are mechanical and not fundamental, so the document could be nominally approved.

Decision 02	WGCV endorsed the <i>Good Practice Guidelines for UAV-based Surface Reflectance Validation</i> , subject to the implementation of final minor modifications proposed by the IVOS Subgroup (largely structural and not impacting the overall principle of the document).
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- Philippe Goryl (ESA, WGCV Chair) noted that at Plenary, we will not look for endorsement, but share the protocol ‘for information only’. One of the major tasks of this group is to work on SR. This is a contribution, but at some point we need something more coherent.
- Simon Oliver (GA) presented on SR in the joint WGISS/WGCV session yesterday, and spoke of precise definitions, some of which are spelled out in this protocol.
- Paolo Castracane (ESA) noted that once the changes are final, we can publish it on the Cal/Val portal.
- Nigel agreed, and that it should have a DOI attached, so it’s a citable document. Maybe ESA or NPL can help with getting a DOI.

- Michael Cosh (USDA) noted that LPV does this for NASA protocols.
- Valentina noted that if the data is made available on the Cal/Val portal, it would either follow the latest version of the protocol, or the data used to reach the protocol, so this needs to be figured out.

2.6 - GHG Cal/Val and Network Updates

Philippe Goryl (ESA, WGCV Chair) introduced the session, noting that GHG discussions are very important within CEOS, and took up a lot of discussion time at the latest SIT meeting. The resultant document was well-written and useful.

Jean-Christopher Lambert (BIRA-IASB) and Akihiko Kuze (JAXA) reported [\[slides\]](#):

- The Greenhouse Gas Task Team (GHG-TT) has developed version 2 of ‘The Roadmap for a Coordinated Implementation of Carbon Dioxide and Methane Monitoring from Space’, which will be presented at the next CEOS Plenary for endorsement. Jean-Christopher and Kuze-san are involved in preparing the Cal/Val portions of the document. There were many contributors and these Cal/Val inclusions are always a first in these kinds of documents.
- The Cal/Val portions were written to show how and why it’s important. Calibration and L1 products are strongly related. The section calls for traceability to commonly accepted reference standards, with known uncertainties quantified across multiple sensors to improve resolution or coverage, or extend the data record beyond the operating lifetime of a single space-based sensor.
- The document’s focus on Research to operations makes the interoperability of L1 products important.
- The current existing GHG satellite observations are mostly from SWIR and some TIR measurements.
- Pre-launch calibration is important for GHG measurements. CO₂, CH₄, and aerosol measurements are subject to uncertainties, so pre-launch calibration is important and needs to adhere to standards. However different countries implement different standards. For example, GOSAT uses the Japanese AIST standard, and OCO uses NIST.
- TIR is quite different in calibration, as some bands are heavily dependent on the space environment. Onboard calibration standards are required to minimise these environmental effects.
- In the document, we explain the traceability to commonly accepted reference standards, and the need for multiple sensors to improve the resolution or coverage. GHG monitoring requires 20-30 year time series data, so traceability is important.
- Work was done initially through bilateral agreements among specific missions, and recently, key CEOS activities within WGCV/ACSG and within WMO/CGMS GSICS.
- The majority of GHG assessors use the moon as a reference, although there are issues with the polarisation sensitivity of the lunar surface. So we need more data on lunar calibration.

- Jean-Christopher presented on GHG Cal/Val Networks updates regarding new instruments and deployments, harmonized data processing, campaigns, and a new GHG Cal/Val planning and ground-based network design tool.
- TROPOMI on Sentinel-5P serves as a pathfinder for CH₄ and CO operational validation fed by the 3 GHG column/profile monitoring FTIR networks, NDACC FTIR, TCCON, and COCCON.
- In parallel, validation activities are performed for every data product, whereby an automated validation server runs automatically providing near real-time data.
- TCCON and COCCON provide data with some latency. There is progress toward central processing, but it's not operational yet. A new version of COCCON software has been released, and the reprocessing of all stations is in progress.
- Plots (shown on slide 6) show data latency and latitude coverage, validating TROPOMI data within requirements.
- Each of the three networks have their strengths and weaknesses. Over the last year we have communicated to the GHG TT and presented at the previous SIT meeting. This is ongoing work, the networks are progressing step by step and within the limits of their resources.
- The three networks are now acknowledged in the GHG Roadmap version 2 with high level issues highlighted. Annex C to the roadmap - Implementation Actions is a living document describing more detailed actions and issues.
- A new Cal/Val planning and ground-based network design tool was developed in support of CO₂M and related missions. This tool visualises the networks to derive conclusions such as the completeness of the validation capacity.
- There are a number of new GHG Cal/Val stations and instrument deployments. Measurements have begun from CHARS (Canada), Porto Velho (Brazil), and the Yucatan Peninsula. There are two new planned FTIR sites in India, and a growing number of LR spectrometers. ESA's SVANTE is a four-year support of several IR and UV-Vis campaigns dedicated to Sentinel-5P validation.
- Kuze-san discussed the Matchup dataset for SWIR-TIR intercomparison. Even using GOSAT and GOSAT-2, there are difficulties. Results between OCO-2 and 3 have biases, and we want to investigate why.
- Intercomparisons between spectral bands were done between solar reflective sensors like GOSAT, TROPOMI, and TEMPO and new-gen GHG sensors like CO₂M and GOSAT-GW.
- The intercomparison between GOSAT and OCO-2 found that over desert areas, differences in geometries increase uncertainty. The GOSAT and AIRS matchup did not target temperatures, but CO₂ and CH₄ emissions.
- Wide temperature ranges of measurements suggest that the target is near the surface. Calibration uncertainties are generally temperature dependent. Retrievals need to be stable and seamless between multiple sensors.
- GOSAT and OCO-2 operate well, but the biases need to be reduced.

- GHG Cal Val Railroad Valley (RRV) campaigns have run since 2009 and include radiometric calibration results for 6 instruments: intercomparison of satellite data, and satellite measured vs. calculated radiance at TOA using campaign data.
- Preliminary L1 data was shared, which includes degradation correction for each instrument. Uncertainties are as small as 7%, and most are smaller than 5%. OCO-2 always has smaller biases. BRDF Corrections make the largest uncertainties.
- Kuze-san shared John Worden's input summarising the methane emissions best practices document in development:
- Most of CH₄ emissions are from point-sources like oil and gas fields. These measurements are increasingly being made by both the public and New Space sectors.
- We need a set of best practices for facility scale observations, and to define what is expected of the community and emitters while ensuring emission estimates are reproducible.
- Next steps include the continued support in defining best practices for quantifying and reporting emissions, and identifying the need to extend the best practices to area fluxes.

Discussion

- Philippe asked if the detail 'Identify and encourage sharing pre-launch radiometric, spectroscopic and geometric standards and methodology for their use in calibrating GHG sensors' has happened.
- Kuze-san explained that pre-launch radiometry has been done, so we have a framework already in place.
- Nigel Fox (NPL) asked if this calibration is only encouraged and demonstrated for the two mentioned missions.
- Kuze-san noted that the process has also been done for Microcarb integrations using validation processes whereby retrievals between Microcarb and OCO are compared.
- Nigel asked how sensitive the retrievals are for CO₂ and CH₄ for radiometric calibration.
- Kuze-san explained that ten years ago, the goal was 1 ppm, for estimating the uptake from the oceans. Now, the requirement is 5 ppm. Most of the people say 3% uncertainty. At the beginning of the project 20 years ago, this was targeted at 20%. The goal for pre-launch calibration was getting down to 3%. This was attempted, but there are many uncertainties remaining from factors like BRDF correction.
- Nigel noted that in the context of SITSats, yours seems to be a potential example of where, not directly, an improvement in radiometric uncertainty has a benefit in the values for GHGs. A high impact example that would be worth exploring.
- If, for example, a 10% to 3% reduction in uncertainty makes a factor of 2 improvement, it's something we need to explore. We have the ability to improve the radiometric and BRDF calibration for these sensors, and it will have some impact on the end result.

- Jean-Christopher reported a discussion on this at the AC-VC meeting last year. The L1 to L2 product has many sources of uncertainties. To improve it over the oceans to monitor uptake they need to improve the L2 part with better calibration of retrieval algorithms. Radiometric calibration certainly plays a role, but it's not the sole player.
- Nigel wondered if we can accommodate a value noting what we can potentially control.
- Philippe noted that as New Space grows, the next VH-RODA is open to atmospheric missions like the Tanager hyperspectral mission.
- Jean-Christopher noted that the next challenge is validating not only vertical columns but also fluxes for GHGs, NO₂ and SO₂ plumes. The quality of SO₂ measurements need to be explored more.

2.7 - Atmospheric Composition Subgroup (ACSG) Report

Jean-Christopher Lambert (ACSG Chair, BIRA-IASB) reported [\[slides\]](#):

- The 'Best practices protocol for the validation of aerosol, cloud, and precipitation profiles' first draft was circulated with the EarthCARE validation team in February. The document was updated by September 2024 and distributed for CEOS review and endorsement (CV-22-01).
- The document includes:
 - Validation needs for space profilers
 - Survey of validation measurements
 - Correlative metadata and data format
 - Guidance for the validation of lidar and aerosol products
 - Guidance for the validation of Radar, cloud and precipitation products
 - Statistical validation
 - Near-real-time validation through monitoring in NWP data assimilation system
 - Gaps and challenges
- The document was circulated within WGCV and other groups several weeks ago, and some ground-based feedback has been received, but there was nothing substantial from CEOS. The document will be presented officially at CEOS Plenary 2024.
- Philippe noted that the strengths of the document lie in the wide international collaboration. There were no objections and the decision was made for its formal endorsement at WGCV-54.

Decision 03

WGCV endorsed the *Best Practice Protocol For The Validation Of Aerosol, Cloud, And Precipitation Profiles*.

- ESA validation related activities for EarthCARE include collaboration with the EarthCARE international validation team (43 Cal/Val projects), JAXA, NASA AOS, and pilots for atmospheric satellite missions.

Further activities include FRM developments for lidars, radars, and imagers, and pre and post-launch campaigns.

- There were three prelaunch validation workshops with substantial work on data formats. The EarthCARE products are complex, and everything is described in the EarthCARE Scientific Validation Implementation Plan.
- There is a long list of ground-based, shipborne, and airborne measurements underway. 53 stations participate in ATMO ACCESS, which encompasses 2 pre-launch rehearsals, intercalibration with other systems, bespoke data processing, and a dedicated mission commissioning campaign during the EarthCARE commissioning phase.
- There is ongoing collaboration with 22 airborne campaigns from national scientific institutions, which are a mix of dedicated validation campaigns and collaborative piggybacks. The locations of airborne campaigns encompass Arctic, mid-latitudes and equatorial regions. The site of Palau in Micronesia near the Philippines is recognised as an ozone reference measurement site and a good candidate for campaigns and more permanent measurements.
- Pre-operational L1 data is available to validation teams. L2 will be released between October 2024 and February 2025. Validation workshops will be held in January 2025 for L1 data virtually, by March 2025 for L2A in Frascati, and December 2025 for 3- and 4-sensor L2B in Tokyo.
- The first phase of the IGAC Tropospheric Ozone Assessment Report (TOAR, 2014-2019) had revealed issues with the satellite data available at that time. In response, the CEOS activity VC-20-01 has been set up to address these issues as a contribution to the second phase of TOAR (2020-2024), with the main objective being to better harmonise and validate datasets with a more consistent approach to tropospheric ozone.
- Improved and harmonised satellite data resulting from VC-20-01 contribute now to several TOAR-II papers. The community papers deadline is November 30th 2024, and summary papers will come after in 2025.
- The TOAR-II Focus Working Group: HEGIFTOM (Harmonization and Evaluation of Ground-based Instruments for Free Tropospheric Ozone Measurement) has output the major deliverable: Quality assessed ozone data sets from established ground-/air-based instruments, whereby each measurement gets also an uncertainty and a quality flag, with representativeness and instrumental drifts characterised and evaluated.
- A table of ground-based and free tropospheric measuring platforms was shared, with the outcome of a database of improved and harmonised data records.

Instrument/Platform	Time period	Coverage/Network	Groups in HEGIFTOM
Ozonesondes	1965 - present	> 50 Sites worldwide (GAW/WOUDC, NDACC, SHADOZ)	RMI (Belgium), FZJ (Germany), ECCC (Canada), NOAA (USA), NIWA (NZ), NASA (USA)
MOZAIC/IAGOS	1994 - present	Cruise altitude (10-12 km) & Airports worldwide (100-250 Airports)	CNRS (France) & KIT (Germany)
FTIR	1995 - present	NDACC, 13-15 sites having more than 10 years of data	BIRA (Belgium), NCAR (USA), AEMET (Spain)
Lidar		NDACC, TOLNET (9-10 Sites)	NASA (USA), LATMOS (France), UAH (USA)
Umkehr (Dobson & Brewer)	1956 - present	WOUDC (> Sites), NEUBrew, EUBrew (14 Sites)	NOAA (USA), MeteoSwiss (Switzerland), BoM (Australia), NIWA (New Zealand), OHP (France), AEMET (Spain), Univ. Thessaloniki (Greece)
MAX-DOAS	2010-present	5-10 sites NDACC and associated sites	BIRA (Belgium)
Pandora	2012 - present	> 40 sites at 2020, Pandonia Global Network (PGN)	NASA (USA), VTU (USA), LuftBlick (Austria)

- AC-VC-20 occurred this week in College Park, MD. The next meeting will be hosted in Japan in June 2025.
- There are three CEOS activities still open with many activities related to air quality constellation validation. At WGCV-53 Larry Flynn proposed a common activity, with common spectra to be analysed by different teams involved in the geostationary missions GEMS, TEMPO and Sentinel-4 and in the LEO missions. There is a lot of collaboration on FRMs and validation campaigns.
- Set-up in 2017, the ESA/Copernicus Sentinel-5P routine validation service is still running operationally, with continual development to extend data procurement from the different ground-based networks. The Sentinel-5P service serves as a pathfinder for the ESA PEGASOS validation service for GEMS, which will be extended to TEMPO.
- Collaboration opportunities for Cal/Val of the Air Quality Constellation include the GEMS AO, the TEMPO Mission Validation Plan, and the joint ESA/EUMETSAT AO Call for the Cal/Val of Sentinel-4 and -5.
- The Third Cabauw INtercomparison of DOAS-like Instruments (CINDI-3) intercomparison campaign took place last spring, and was successful. The campaign was a semi-blind intercalibration and intercomparison campaign with external referees. The ambition is to intercalibrate MAX-DOAS like instruments, to have them certified for NDACC and ACTRIS-CREGARS, and have them responding better to user needs and to satellite validation requirements.
- CINDI-3 (CV-24-01) involves 35+ UV-VIS MAX-DOAS instruments intercompared from 16 countries. 60+ instruments were deployed from 100+ participants. UV-VIS MAX-DOAS, SOAZ, and Pandora types were intercompared for NO₂, HCHO, O₄, CHOCHO, HONO, BrO and O₃ slant column measurements. There was a good first agreement between measurements. Data analysis is in progress.
- CEOS-FRM version 1 received substantial feedback from ACSG and the NDACC Steering Committee.

- Version 2 is in progress, as will be reported by Paolo Castracane later this week. The V1 metric is applicable to a measurement and hence classification. Version 2 now also presents an additional column characterising the validation capacity achieved by a network deployment or other kinds of measurement deployments or series, centralised data processing, timeliness, and QA/QC. This column is not a classification criteria. V2 development is in progress. There are test cases volunteering for future V2 included NDACC sub-networks, and ACTRIS-CREGARS.
- The status, issues and challenges regarding FRM data provision and future plans were reported at the WMO/UNEP Ozone Research Managers meeting (Geneva, 2024/04) and QO3S (Boulder, CO, 2024/07). FRM status and challenges for the AQ constellation validation will be reported at AGU FM 2024 (Washington DC, 2024/12).
- ESA Living Planet Symposium 2025 (Vienna, 2025/06) will have a cross-EO domain session on ‘Recent progress on uncertainty analysis for Earth Observation measurements’, and is open to FRM and uncertainty characterisation presentations.
- The NDACC network strategy peer-reviewed paper is making good progress, and includes satellite validation perspectives for NDACC sub-networks and the viewpoint of stakeholders.
- The NDACC 35th Anniversary Scientific Symposium 2025 will take place in Virginia Beach, VA, USA in October 2025.

Discussion

- Philippe Goryl (ESA, WGCV Chair) asked if there were plans for a meeting of the subgroup before the next WGCV in July.
- Jean-Christopher noted that there are discussions to hold an ACSG meeting potentially in spring in Tokyo, in collaboration with AC-VC.
- We could maybe write rules for the Cal/Val portal once we have enough publications. An update to the Cal/Val Portal was discussed, in order to increase the reporting of domain activities. The subgroup should have a reporting page that links to material of the subgroup’s activities.

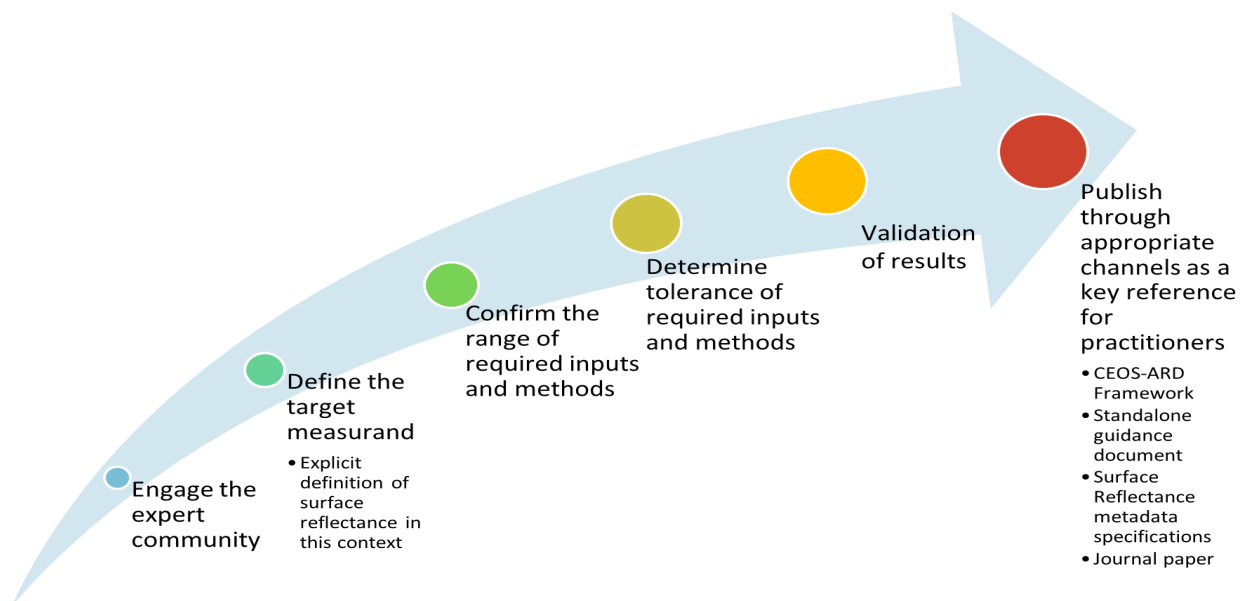
WGCV-54-08	Paolo and Jean-Christopher to update the CEOS Cal/Val Portal with details of recent activities of the Atmospheric Composition Subgroup (ACSG).	Q4 2024
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2.8 - Surface Reflectance Quality and Consistency

Simon Oliver (GA) reported [\[slides\]](#):

- This session was intended to discuss opportunities for WGCV within the SR Quality and Consistency activity.
- CEOS-ARD provides a strong basis for interoperability, and this project is seen as taking the next step in the interoperability continuum.
- Simon recapped the material shared in the joint session yesterday.

- The project is currently at the first stage of the action plan, 'Engage the expert community'. The group is working towards defining the target measurement and the tolerances for the inputs to corrections and the validation steps that follow.



- The effort seeks to draw the line at harmonisation for equivalence between like bands.
- Thought has gone into the measurand definition, as a type of SR measurement using the work of existing publications like Nicodemus. Achieving consistent measures across providers requires bounds to the inputs acceptable to achieve these processes.
- A lot of mission-specific consistency exists, but significant opportunity exists for multi-mission approaches.
- Simon's questions to WGCV:
 - Should measurement-level consistency of surface reflectance datasets across providers be a goal for CEOS agencies? If not, why not?
 - The guidance document for SR quality consistency is a collective body of work in progress from many contributors, we are seeking feedback on the work done so far. Are there changes we could take in our approach?
 - Could WGCV help with reviewing or provide critical input to progress this work further?

Discussion

- Nigel Fox (NPL) asked why the tolerance of values needs to be defined. Is it just to be sure that people include them in radiative transfer models and then use that to correct SR? You don't need to force everyone to do that harmonisation.

- Simon noted that providers might use a default aerosol measure. The idea is to have an aerosol input to the model which has to be a known uncertainty. The wording is a bit general so the language could be tightened.
- Larry Flynn (NOAA) noted that there is a missing implicit thing between being within what people are bringing to the discussion. Kurt Thome noted that it depends where the radiative transfer model keeps its uncertainties. Peter noted that you need the right input for the right algorithm.
- Simon explained that part of the journey to get here has resulted in terminology issues.
- Larry via chat: *"Parameters must be 'quantifiable or accurately estimated' within ..."*
- Simon explained that we're focused on the quantity definition itself, but consciously don't say that there is one method to get to the quantities. We have this collection of SR products but they're not equal. This work is trying to identify that quantity that could be put together as a harmonised set of data.
- Peter Strobl (EC-JRC) noted that the first statement should be obvious, as the basis for all metrology. When measuring the same thing with different means, the results within the uncertainty have to agree.
- Nigel was concerned about the question. You want to be sure that you have the same consistent definition, and then you want the same knowledge of information associated with parameters to derive that value.
- Philippe Goryl (ESA, WGCV Chair) suggested that we force everyone to produce BRF. Kurt added that even when saying BRFs, there are multiple different types. Peter said that the question is that if you pick one, everyone should produce for that one result the match. Different measurement, different question.
- Cody Anderson (USGS, WGCV Vice Chair) noted that under different view angles, measurements are inherently different. Can't get consistency if you don't have the same sensor and same angle in the atmosphere.
- Kurt Thome (NASA) asked what the consequence is of a group that starts tuning approaches.
- Peter added that depending on the application, will such a process bring the uncertainty down? Copernicus still faces the question of using L1 over L2 for certain classification processes. Begs the question of whether it's worthwhile being produced. It makes no sense if half of us go in another direction which would kill interoperability.
- Medhavy Thankappan (GA) added that we need to agree within the CEOS context first.
- Michael Cosh (USDA) noted that SR is an intermediate product to get something more usable to the public. Meeting some internal metric could take a lot of time. Some providers are not going to share and will develop proprietary methods. Can we force them to demonstrate consistency in order for governments to purchase data?
- Peter suggested that it could become a prerequisite for an ARD spec. Philippe added that what we are trying to do is a kind of CEOS-ARD+.

- Nigel noted that as a prerequisite to ARD, this should have been done before ARD. The prerequisite of ARD is to aid interoperability. If it's not the same measurand, you'll never have interoperability.
- Cody added that some threshold requirements for SR in ARD include BRF and terrain illumination, which are in this definition.
- Peter suggested that it would be better to have a clear cut description of the measurement, that is phrased in a consistent way with what others do. We could easily define different spectral reflectance, each in their own right, measurements.
- Nigel suggested making the requirement to define the measurand as part of the self assessment. Peter added that this is not what the ARD PFS is for.
- Medhavy pointed to the table Simon shared initially, which called for people to say what their version of SR entails.
- Kurt noted that this could be done, it's what RadCalNet does. They go to test site providers and ask for a certain product with an error budget. It has been done within CEOS with a well known customer base provider and problem. This is much broader.
- Peter noted that if we want a common SR product, we have to be sure that it is a really good fit for purpose, and only if it justifies all the effort of doing it, then it could be produced in the next collection effort.
- Philippe suggested updating the PFS to include this.
- Peter noted that Australia is a customer that needs an intermediate product with certain interoperability.
- Simon added that there was the same argument around NASA HLS and Sen2like products. Natively, they are not compatible enough for a harmonised product. In order to get a consistent time series consistent with compatible measurements.
- Kurt asked if we compare the validatability of the product?
- Peter had a discussion that some of these measurements cannot be measured. The non-measurable quantity would be the most stable to use as a common base. Cannot be measured by is a good offerable platform as it's well a defined physical parameter. You need a model regardless of what you define.
- Philippe asked if SR is done by LPV or IVOS? Nigel noted that it's split between the two, and Michael explained that LPV defines 'Surface Radiation' for SR.
- Medhavy noted that getting a collective expertise on this would be a good first step to help us understand the nature of the problem.
- Peter would like to get the users of the product, the LPV people, in order to underpin requirements for the SR definition.

- Kurt asked what SR is SR1X4Veg comparing? Michael answered with HDRF, although it is very ‘under the hood’. Petabytes of data are coming through this. LPV are likely basing downstream products based on this intermediate step.
- Kurt noted that the most widely used products rely on remote atmospheric correction to a directional reflectance with BRDF correction. Peter added that scale also plays a role.
- Michael suggested that having the producer state what they did and how they did it is a good minimum compromise.
- Brian Terry (SEO) noted that multiple observations are required to get to the timeseries, although Micheal added that metadata info allows everybody to go back to raw format.
- Kurt noted that ATBDs now exist more as a checklist, which misses the flavour of the original process.
- Brian noted that the goal of consistency is to take multiple observation platforms and combine them into a single time series. Multiple observations need a common format that makes sense.
- Cody added that you’re throwing away some data on the way, and stopping before spectral band adjustment.
- Kurt asked if we had decided who our customer was.
- Philippe noted that it would be nice to have a dedicated discussion between LPV and IVOS with a structured discussion on what we want to achieve.
- Nigel suggested that the appropriate questions are phrased to the appropriate group of experts. Rather than have another group, maybe just make sure we have a meeting of the SR group and have the WGCV members invited. As a result, the SR PFS will need to be updated.
- Peter noted that the point in LSI-VC is that it currently does not look beyond L2 SR. What we are missing and slowly getting are more demands for higher level products. LPV are the ones for quality.
- It’s important to think of the main scope being addressed, so we should offer meetings of what we have, then open the floor to what they have to say.
- Medhavy recalled USGS Collection 3, in which any meaningful inputs need to be made quickly.

WGCV-54-09	<p>Medhavy Thankappan, Simon Oliver, and Cody Anderson to prepare some questions specifically for LPV, IVOS, and LSI-VC regarding the Surface Reflectance Consistency project and organise a follow up discussion with these groups, including the potential formation of an <i>ad hoc</i> group under WGCV.</p> <p>Philippe Goryl to raise at the next CEOS Secretariat meeting at CEOS Plenary 2024.</p>	Q4 2024
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- Paolo Castracane (ESA) shared the SR definition paper by Schaepman:
https://calvalportal.ceos.org/documents/10136/11045/doi_10.1016_j.rse.2006.03.002.pdf

2.9 - Land Product Validation (LPV) Subgroup Report

Michael Cosh (LPV Chair, USDA) reported [\[slides\]](#):

- The LPV subgroup concerns the end user and serves those who need the data. The group has 12 focus areas from biophysical to aboveground biomass, with the new additions of evapotranspiration and GPP/NPP.
- A list of the Focus area leads were shared. Michael will be replaced by Fabrizio Niro as LPV Chair in April and is looking for an US or North American representative for Vice Chair.
- Many protocols for validation have been developed, where some within the 2024-2025 range have been sent out for public comment. The plan is to send them out in their final form for WGCV to give any final comments, with some endorsement coming out of WGCV-55.
- Biophysical products are currently available for Europe and North America. The Biophysical Focus Area group is making a good practices update, and is aiming to make definitions fluid enough to accommodate new ones. There are sections on high resolution and 3D data products. The 3D point space is massive in volume and GPU usage.
- The Fire/Burn area protocol is 34 pages long. Burned area and active fires are similar in interest but not in methodology. A Burned area product is currently in development.
- Under the Phenology Focus Area, the Copernicus Land Monitoring Service (CLMS) has signed a contract for the continuation and evolution of the high resolution vegetation phenology and productivity (HR-VPP) product suite. The product's calibration report will be published in Autumn 2025.
- The Vegetation indices Focus Area formed a small group of experts to review the protocol's development. The first draft was completed last year, and the full version is nearly done.
- The Land Cover guidelines document is in the revision process now, and LPV would like this endorsed for WGCV-55. The Land Cover contributors met last fall. The document will be finished within a couple months and distributed to WGCV. It can be submitted through NASA in order to get a DOI.
- Snow is one of the evolving topics with a vibrant validation community. Training sessions are held each year, although it lacks a long term viable sensor in space. There are no plans yet for a protocol because of SnowPEX. LPV are working with a broad snow community within GCOS for discussions.
- The Surface Radiation Focus Area group is making the 2024 update of SALVAL (Surface Albedo VALidation) tool, with new LANDVAL-V2 sampling for product intercomparison.
- There are many different communities within visible space at LPV. Some differences between focus areas like Vegetation Index and Biophysical are apparently vague.
- Relevant projects under the Soil Moisture Focus Area include FRM4SM, ESA CCI, and EURAMET Green Deal Call 2024. A good practices protocol for soil moisture exists, and will have a radar-based product when NISAR launches. Upcoming soil moisture workshops include BIPM-WMO Metrology

for climate action WS 2024, and special sessions at EGU and LPS. There was one recently in Michigan as they're trying to have every 2 years.

- There are a lot of issues with manufacturer consistency across drone based thermal sensors, which relates to the TIRCalNet preparation study.
- The Above Ground Biomass V2.0 protocol is currently being drafted. Two papers that use GEDI and ESA CCI forest biomass estimates are currently in review.
- The operational establishment of the Forest Biomass Reference Network (GEO-TREES) is in progress.
- Evapotranspiration (ET) had recent workshops at the WGU Chapman conference, the International Science Workshop on High-Resolution Thermal Earth Observation, and the ECOSTRESS Science Team meeting. The three primary ET products include Evaporative stress index, SERVIR Global ESI, and ECOSTRESS.
- The Earth Observation Assessment report for agriculture and forestry was an effort within the US to do a societal benefits area analysis of all Earth Observations, and is evolving to break up disciplines.
- In situ field work has multiple inputs into the USGEO EO assessment. An interactive table was produced which can show the most important inputs for applications like food supply. It is currently only applicable to agriculture and forestry, but is planned to be expanded.
- In land products, the goal is to define the best 'bang for your buck' and quantify the valuation of the dataset. There is a need for a review on satellites which contribute to LPV development, not just in primary, but in ancillary datasets, both public and commercial.

Discussion

- Philippe Goryl (ESA, WGCV Chair) expressed that Land Cover is a good contributor to the CSA CEOS Chair Biodiversity theme. We had the discussion within biodiversity, and missed the formal connection with the group. The Land Cover document should be sent directly to the biodiversity people, e.g. GEOGLAM and AFOLU, for information, feedback, and application.
- Peter Strobl (EC-JRC) noted that LPV is looking into the quality for these areas, and we need a home for that in terms of Virtual Constellations. LSI-VC should pick these topics up and integrate them into their domain.
- Michael added that GEOGLAM and the international community was very involved with this.
- Peter was interested in the terminology used in the document, as there is a kind of acknowledged ontology for these products.
- Michael noted that looking at how and why the data is used helps define the way to go. A vegetation index can be used for phenology. Groups would focus on vegetation index as a collected parameter, then folks using it to go to phenology.
- Peter related to how similar approaches create practical problems in the Copernicus Land Service for organising products in a tree.

- Kurt Thome (NASA) shared that there would not be an update to the vegetation indices in MODIS Land Cover product V6.1, as funding to the VI community was basically taken away.
- Philippe noted that LPV is the one who is doing the best in terms of documentation publications. WGCV contributes well to the CEOS Chair biodiversity theme, especially with LPV's protocols. Philippe will mention LPV's efforts at Plenary. The extension to the new GPP is also a great contribution. The BRIX-I Workshop was good but small, maybe it will be more relevant once the mission launches.
- Philippe asked what is needed in terms of calibration from this community, and was curious if the agricultural calibration standards can be improved by SITSats.
- Michael noted that specifically to CLARREO-PF, if something's 'under the hood', and not apparent to the person using it, that's the most important aspect. We'd have a deliverable at USDA like a cropland datalayer, where the survey would ask the confidence in the data based on potential alterations to the data. If it's too far under the hood, CLARREO-PF's contribution may not get recognised. There is some bias removal in analyses of these EO assessments to ensure account of different requirements.
- Peter noted that if you never allow for upgrades, you can never improve. In defining continuity so stringently you will never improve.
- Michael noted that sometimes new data records don't get accepted unless they have 30 years of heritage.

Day 2: Thursday 17 October, 2024

3.1 - Welcome and Review of Day 2 Actions

Harvey Jones (WGCV Secretariat) reported:

- *Action-01: In support of the SITSat Task Team's communication strategy, WGCV members are asked to help gather examples/case studies regarding 'real world' impacts of the reduction in uncertainties that are facilitated by SITSats.*

We seek to show the unique value of these types of missions and highlight differences between usual calibration practices and those provided by SITSats. Examples should be accompanied by clear, transparent metrics (financial, improved decision-making, etc.).

These examples will be presented at a dedicated session at the Living Planet Symposium in June 2025.

- This action refers to the presentation of examples/case studies of SITSats at Living Planet Symposium in June 2025. These would not be presented by Nigel as he only chairs the session. Abstracts from the community will present at the session.
 - Kurt Thome (NASA) asked if we have a good idea of a list of data products and uncertainties.

- Nigel Fox (NPL) noted that we have products in Sentinel-2 and uncertainty, but was unsure that we have a full list of products and uncertainties. Part of the problem is that we have no quantitative values. It would be good to have these listed on the Cal/Val portal.
- Cody Anderson (USGS, WGCV Vice Chair) noted that Bob Ryan and Mary Pagnutti’s paper on L1T uncertainties should be published by LPS.
- Nigel asked if it is tied to an application, i.e. what does the user do with it, and thought that Landsat did a study on applications and uncertainty requirements. Cody noted that this has been an open action within USGS.
- Kurt noted that the LAI product from MODIS would present a good idea of L2 data, although acquiring it would take a while. Nigel noted that this action was to ideally gather high-impact easy examples of uncertainty reductions, and that Kurt’s more generic input is broader than SITSats, and might lead more to the finding of these impacts.
- Yolanda Shea (NASA) noted that generating a list of uncertainties on L2 data products and the uncertainties by other communities can help identify gaps. SITSats can help, but would be a multi-year effort. ‘What uncertainties can L2 products achieve?’ is a good step.
- Kurt asked if CLARREO-PF could put together a VIIRS and CERES product? Yolanda responded that it may be difficult but can work on this.
- Kurt asked similarly if there is a targeted sensor package for TRUTHS? Nigel confirmed that they plan to deliver an initial package of sensors to provide a tailored service for Sentinel-2 and -3, FGI (MTG Geostationary), CO2M, Landsat. Just what the ground segment will initially deliver.
- Kurt suggested we gather a table of Sentinel-2 products and their uncertainties. Philippe noted that if you ask providers for L2 requirements, most will say they don’t know. Nigel added that SITSats will enable us to actually give the info to derive these products in the way they should be.
- Yolanda noted that the first step is to identify high impact areas, starting with core emission targets that make it relevant to TRUTHS and CLARREO-PF. It may be a bit overwhelming for the SITSat team to gather all this info, so the effort should be to just get the ball rolling first.

WGCV-54-02	WGCV members are asked to identify for priority target missions of SITSats a list of their products and associated uncertainties.	June 2025
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- *Action-9: Medhavy Thankappan, Simon Oliver, and Cody Anderson to prepare some questions specifically for LPV, IVOS, and LSI-VC regarding the Surface Reflectance Consistency project and organise a follow up discussion with these groups, including the potential formation of an ad hoc group under WGCV.*

Philippe Goryl to raise at the next CEOS Secretariat meeting at CEOS Plenary 2024.

- This project was formulated as part of the work plan as a cross cutting theme, and should be supported by an *ad hoc* task team. We want to formalise it a bit more, and are unsure where it belongs.
- Medhavy Thankappan (GA) suggested that capturing the intention that we want to formalise as a cross cutting action is a starting point.
- Steven Ramage (CEOS Executive Officer) suggested taking it to the Secretariat as an action for the Work Plan, and raising it as a topic at the next SEC meeting.
- Medhavy flagged this to Jono, and was unsure if it's too late to raise this as part of the formal agenda for Plenary. Suggested adding it to the WGCV Chair report. We need to make sure we have sufficient focus on this issue.
- Brian Terry (SEO) suggested naming it an *ad hoc* task team.

3.2 - Microwave Sensors Subgroup (MSSG) Report

Xiaolong Dong (MSSG Chair, NSSC) reported [\[slides\]](#):

- MSSG covers several different microwave sensors including radiometers, scatterometers, GNSS Radio Occultation (RO), and reflectometry. The group is preparing new tasks under GNSS-RO and reflectometry.
- Ongoing tasks include CV-20-05, the Retrieval and validation with high winds with combined active-passive microwave measurements, and CV-23-06, the Retrieval and validation of sea surface atmospheric pressure with microwave remote sensing. Both are planned to be finished in Q2 2025.
- CV-20-05 is for the monitoring of extreme surface winds using satellite-based microwave sensors, which is important for risk management authorities and the oceanic and atmospheric communities. Current scatterometers or radiometer-derived winds are far from the truth, and require recalibration. The Task team for this includes NUIST, NSSC, KNMI, NOSAS, NSMC, and NOAA contribution. The deliverable is to provide a comparison of respective wind results from both types of sensors and examples of joint application methods for high wind retrievals.
- Progress of validation reference aspects include the collocations of storm-centric coordinates and improvements to spatial representativeness, and satellite data aspects include analysing sensor sensitivities under high and extreme wind conditions, the recalibration of radiometer brightness temperature and radar NRCS (ongoing), and high and extreme wind validation using the reference data. The remaining task is for direct measurement.
- The summarised task progress was listed:
 - SFMR-based readjustment of scatterometers & radiometers has been done, and SFMR spatial representativeness effects are analysed.
 - ASCAT readjusted winds used as reference to readjusted Ku-band winds and REMSS radiometer (AMSR-2, Windsat, SMAP) & Ifremer SMOS wind products.

- Error characteristics of different calibrated high-winds have been studied using triple collocation analysis.
- In the context of ESA MAXSS project, a high wind product has been released through <https://www.maxss.org/>
- Future work includes the re-calibration of radiometer brightness temperature, and radar NRCS (~2025Q1), and the wrap-up and release of deliverables (2025Q2)
- CV-23-06 highlights that surface pressure data is important in NWP, tropical cyclone forecasting, and climate change studies. Ocean surface atmospheric pressure data are measured mainly *in situ* with poor coverage.
- Retrieving surface atmospheric pressure from spaceborne passive microwave observations is achieved by microwave radiometers due to their ability to measure coral columnar oxygen absorption. Advantages of the new technique include all weather and time capability, high spatial and temporal resolution, and wide swath observations (2000 km).
- The Task team has participation from NSSC, the Shanghai typhoon institute, NSMC, NSOAS, and the Hong Kong Observatory.
- The deliverable's objectives are:
 - To develop and optimise the retrieval models and algorithms for sea surface pressure by passive microwave observations.
 - To validate and assess the sea surface pressure data products using collocated *in situ* measurement data.
 - To deliver the all-weather sea surface pressure data product from passive microwave observations.
- Progress from the algorithm aspect includes the development of retrieval algorithms for sea surface pressure by passive microwave observations, the analysis of the relationship between warm TB anomalies and surface pressure fields, and the analysis of surface pressure information from 60 and 118 GHz radiometers to develop joint retrieval methods. Progress from the validation aspect includes the validation of retrieval results from these radiometers using collocated reanalysis data, and *in situ* validations using collocated buoy, ship, and dropsonde data.
- Future work includes to finalise the comparisons of respective and joint retrieval results from 60 GHz and 118 GHz radiometers by Q4 2024, and the wrap up and release of deliverables by Q2 2025. This will include a task report including the descriptions on retrieval algorithm, validation and comparison results, with links to relevant datasets.
- Future tasks for MSSG include:
 - Retrieval and validation of Global Navigation Satellite System (GNSS) radio occultation (RO) atmospheric products

- Calibration, retrieval and validation of Global Navigation Satellite System (GNSS) reflectometry (GNSS-R) products
- GNSS-RO and GNSS-R provide important data for atmospheric and ocean/land surface. Recent progress of GNSS-RO includes:
 - Improved ionospheric residual errors (RIEs) modelling and mitigation methods such as Bi-local, Kappa and statistical algorithms have been developed to optimise the GNSS RO bending angle data quality. They lead to more accurate GNSS RO data products under high and low ionospheric activity conditions.
 - Developed the Planetary Boundary Layer (PBL) retrieval and lower GNSS RO data retrieval algorithms, which lead to more accurate lower height GNSS RO data quality.
 - New validation algorithms are developed to assess the GNSS RO data. Recently the three-cornered hat (3CH) method has been applied to estimate the error variances of multiple datasets by comparing the differences between three different data sources e.g., GNSS RO, Radiosonde and atmospheric model datasets.
- Progress of GNSS-R includes:
 - A numerical weather prediction (NWP) ocean calibration method has been developed to improve data calibration, reducing the errors from calibrations of transmitting power and receiver antenna pattern.
 - A new method using onboard analog automatic gain control (AGC) has been developed to mitigate the impact of radio frequency interference (RFI), which significantly reduces the wind speed error for regions under RFI.
 - A new geophysical model function has been developed for high wind speeds in the tropical cyclones and shows good performance.
- Future work for GNSS-RO includes the further optimisation of retrieval algorithms and the development of a validation methodology and datasets.
- Future work for GNSS-R includes the dynamic calibration of GNSS transmitting power and antenna pattern, and the Cal/Val or wind speeds over extratropical cyclones and polar areas.
- Other work in preparation under MSSG includes:
 - Promote the ISO TS on calibration and retrievals of sea surface wind by radar scatterometry, which furthers the deliverable of task CV-20-05 and CV-23-05. (ISO TC211 plenary in November)
 - Potential MSSG contribution for FRM Assessment Framework activities.

Discussion

- Philippe Goryl (ESA, WGCV Chair) recalled that in the presentation's introduction there was mention of MSSG dealing with radar altimeters. Altimetry has been absent from WGCV in general. In Cordoba (WGCV-53), we discussed what we should do. Dirk/Stephane may talk about this in the SAR Subgroup Report, but we want to get it better represented. Altimetry have their own community

where they talk Cal/Val ect, so we don't want to duplicate our efforts. It would be good to have a report from altimetry in a Working Group. Suggested that we have this discussion and coordinate between MSSG and SAR to explore altimetry further.

- Xiaolong noted that there is a big group for altimeters, and some discussions with the Chinese ocean agency, with connections with European colleagues. MSSG can discuss how to promote this under the WGCV umbrella.
- Philippe asked if MSSG has a team for GNSS-RO? Xiaolong noted that China has a big team for GNSS-RO with collaboration with European countries like Austria and Spain.
- Philippe noted that New Space is making these kinds of measurements, and asked if there was a plan to discuss with the commercial sector. Xiaolong confirmed that there is work being done, and there are lots of GNSS-RO missions. The main issue is how to improve data quality for weather applications.

WGCV-54-10	MSSG Chair to communicate the subgroup's latest activities, in particular the GNSS-RO team and their work, to gauge WGCV participation interest.	Q4 2024
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- Philippe added that agencies like EUMETSAT and NOAA in particular are active in this domain. They are coordinating with GSICS as they are strong in the microwave domain. Xiaolong added that the GSICS microwave subgroup is also from China (CMA), so they have lots of discussions together.
- It would be good to have a strong relationship with GSICS. At the WGCV level we could have a report on how we work with GSICS in the microwave domain, and our coordination in general.
- Xiaolong has been invited to send delegates to the GSICS meeting in March.
- Philippe suggested a continuous action to collaborate with Paolo Castracane to make the group's deliverables visible to the community through the Cal/Val Portal.

WGCV-54-11	Paolo Castracane to work with MSSG to update the subgroup's Cal/Val Portal page.	Q2 2025
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- Philippe spotted a lot of validation techniques, and heard potential for FRM assessment framework activities. Xiaolong noted that MSSG are still discussing this. The work of the subgroup is mainly for the atmosphere and oceans, but there are also measurements for land surface. We should try to define MSSG's contribution to the FRM assessment framework.
- Philippe suggested that he and Xiaolong organise a 1-2h 'brainstorm' discussion with relevant experts before the next WGCV meeting.

WGCV-54-04	MSSG Chair and WGCV Chair to coordinate a discussion on the relevance of the FRM concept and explore the potential for a contribution to the Assessment Framework activities.	WGCV-55
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3.3 - Fiducial Reference Measurement (FRM) Assessment Framework

Paolo Castracane (ESA) and Jean-Christopher Lambert (IASB-BIRA) reported [\[slides\]](#):

- Paolo has developed a webpage on the Cal/Val Portal available that describes the Roadmap towards an Assessment Framework for Fiducial Reference Measurements (FRM).
- The previous action from wgcv-53 was on developing the guidelines, specifically on an update of the atmospheric context with feedback from the exercise that has already been done.
- Considerations of sampling, representativeness, completeness and timeliness bring the following inputs to improving the CEOS FRM Assessment guidelines and the maturity matrices:
 - The intended purpose of the assessment shall be clearly specified in the intro panel.
 - FRM quality assessments and subsequent classification should stick to the validation and traceability of a measurement.
 - An additional column for validation capacity (network and operational perspectives) will be added to the guidelines and to the MM.
 - The aspects in this additional category will not be taken into account for FRM classification.
 - All agreed to maintain only one CEOS FRM Assessment Framework at the WGCV level.
- The idea is to add a new category for ‘completeness, coverage, and distribution’, which includes:
 - Validation Capacity
 - Geographical coverage
 - Temporal sampling
 - Centralised data, processing, quality assessment and adherence to community standards
 - Timeliness
- There has been several feedback to the maturity matrix tool, which outlined that there needs to be a clear description of the intent for each assessment, and have to provide more configuration information.
- It is important to provide the users with documented references that justify their selections. Verification has to be compiled by a different entity with respect to the first part.

Discussion

- Nigel Fox (NPL) is working on a document that serves as the final step of the assessment report, and would also like a database to see the progress of assessments. The database would be for users to search for FRMs suited to their applications. If we have 100 FRMs, no one will search through them all, so we need a search tool to narrow it down. Paolo suggested that this can be done by taking keywords from the assessment itself.

- Some new exercise reports include those from the Brewer Spectrophotometer, the FRM4GHG 2.0 project, and the tropical centre for reactive trace gas remote sensing (CREGARS) in ACTRIS. EUBREWNET is for O3 retrievals with improved calibration and uncertainty characterisation, and demonstrates usage of the Brewer spectrophotometer with higher maturity.
- Jean-Christopher noted that FIDUCEO and GAIA-CLIM are predecessors of the FRM assessment. FRM4GHG relates to COCCON, which falls under Class B according to the CEOS-FRM classification guidelines as applied in a recent paper. We are close to finalising the guidelines within a couple of months. The end of the year is a good target.
- Organising a second exercise was suggested, to include updating the MM from PGN, FRM4DOAS, and RadCalNet as a minimum.
- Jean-Christopher will ask NDACC instrument Working Groups to get ready to evaluate sub-networks that relate to this version 2.
- Nigel asked if we could be more ambitious, and to consider an operational tool perhaps. With all this beta testing, at some point we want to make it there for people to use, instead of just an exercise. The goal is to be in a position where we make it operational.
- Kurt Thome (NASA) asked if the results of the RadCalNet would go into this.
- Steven Ramage (CEOS Executive Officer) drew upon the call for the GEO work programme (Research to Operations). Previous work started with GEO, getting to the application side and end users. The call for proposals deadline is the 31st October 2024 though. There are probably 45 activities with space agencies.
- Philippe noted that according to the result of the updated assessment, WGCV will decide when we go into operation. Nigel suggested that subject to successful beta testing, WGCV will make the FRM QA process and operational system, and target this for the next WGCV meeting. An updated result should be ready a couple months before for circulation.
- Nigel understood that action for GEO is going from research to operations. We're not promoting it as operational, as it's in development and moving towards operational, so it fits within the scope of GEO.

WGCV-54-12	Paolo Castracane to organise a second FRM Assessment Framework exercise to include PGN, FRM4DOAS, and RadCalNet as a minimum. Updates will be reported at WGCV-55.	1 June 2025
WGCV-54-13	WGCV to confirm the readiness of operationalisation and conduct a pre-launch review of the FRM Assessment Framework, and to define candidates for operational usage e.g. HYPERNETS.	WGCV-55

- Nigel noted that one element we need to define is the panel of CEOS experts. This was raised at IVOS, we need to know how we’re doing this verification, and additional people on this panel which have the right expertise we can draw upon. Paolo Castracane (ESA) noted that it depends on the FRM.
- Nigel noted that it’s not just a biased assessment, but that it’s being assessed by those with credible justification, particularly for confidential dialogues. If we’re going to have the system ready in January, we’re asking people to do their assessments, which requires a verification process. A potential interaction to clarify where someone is being subjective.
- Kurt asked if we are comfortable going live with a statement that for the self-assessment, WGCV is in the process of developing a methodology to evaluate the self assessments and provide ratings. Medhavy noted that this is done in CEOS-ARD, and that the guidelines come from RadCalNet framework.
- Paolo noted that the most important thing in the tool is the kind of configuration. We’re in a good position to achieve this deadline.
- Kurt suggested nominating Medhavy to work with the subgroup chairs to identify suitable evaluators of the FRMs by January 2025. Hypernets would be a good one to use when we go live, as would ICOS.

WGCV-54-145	Medhavy Thankappan to work with subgroup chairs to review the Terms of Reference from the RadCalNet CEOS WGCV review panel and identify suitable evaluators of the different types of submissions to the FRM Assessment Framework.	January 2025
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3.4 - Infrared and Visible Optical Sensors (IVOS) Subgroup Report

Nigel Fox (IVOS Chair, NPL) reported [\[slides\]](#):

- IVOS’ mission is to ensure high quality calibration and validation of infrared and visible optical data from EO satellites and validation of higher level products. Validation is limited to things like Sea Surface Temperature.
- IVOS terms of reference include: to address all types of sensors, with linkage to Cal/Val of satellites; look at the requirements and agree on standards specs; identify test sites, encourage observations and intercomparisons; ensure Cal/Val data is released prelaunch and in-flight, and free flowing in access; and to encourage that we evidence metrology traceability in all end-to-end activities in EO product development, not just for instruments but models and algorithms too. The vision is to provide fit for purpose information through enabling data interoperability.
- IVOS’ vision includes:
 - o Pre-flight characterisation & calibration
 - o Test – sites

- Comparisons
- Agreed methodologies
- Community Good Practises
- Interchangeable/readable formats
- Results/metadata - databases
- Shared learning
- Recommendations as appropriate
- The IVOS Work plan is structured into themes. Nigel highlighted the activity of geospatial image quality. After the last IVOS, there was a discussion and debate on geolocation that USGS would find a volunteer to propose topics to explore interest from different agencies.
- Geolocation is particularly relevant to New Space. Having geolocation information to validate GCPIX at high resolution is subject to ITAR from various countries that they may not be able to release.
- IVOS-36 in Tokyo was hosted by JAXA and AIST. The next IVOS meeting will be in the Americas around September 2025.
- There were 22 in person attendees and 13 online. IVOS-36 topics included:
 - Comparison tools
 - QA initiatives (VH-Rhoda & Jacie)
 - Cal/Val methods/Services (RadCalNet, Hypernets, VICALOPS, RT-Code, global)
 - Impact of Solar Irradiance spectrum change
 - ‘Test-sites’ + Moon
 - Sensor performance assessment and status (particularly JAXA missions)
 - GHG (JAXA special session)
 - Hyperspectral sensors
 - Uncertainty, Traceability, interoperability: what and how
 - CEOS WGCV projects/Actions: - SITSats, FRM (QA), Pre-flight,
 - TIRCalNet
 - Communications
- Regarding the introduction to JAXA future initiatives, the private sector will lead some constellations of high resolution sensors, and the development of this integrated Earth environment towards a digital twin of the Earth.
- The WGCV GHG effort saw results and changes observed in the 2023-4 timeline, which shows how important regular measurements are. AIST’s activities on the calibration of ASTER indicate the shift in

measurement results over time. Consistent vicarious measurements of the AIST and RadCaTS team have been made over an approximate 10 year period.

- DIMITRI is an ESA tool for comparing sensor to sensor parameters over different methodologies. Bilateral information and moving toward a web-based tool called VICALOPS that is more interactive for users, which is planned for beta testing in spring.
- Work is subject to publication, but there was a recent presentation talking about using global observations from Landsat-8 and 9, and comparing global between the two to measure the relative difference between sensors. This is a novel approach to use all information, and includes clouds and different scene conditions which produces consistent results. There is an effort to generalise it to account for different sensors with spectral band differences.
- IVOS reviewed the activity on a subset of selected L1 reference sites. The basis of the recommendations formed were proposed at the last WGCV meeting, which has now been drafted and submitted.
- The desire and need for a Cal/Val infrastructure and database that could report on the capabilities of Cal/Val methods was reiterated. This effort was proposed at the last WGCV-53 (CV-17-01), and interest was confirmed at IVOS-36. The action is to work with Paolo on the Cal/Val Portal.
- The SRIX4Veg protocol was reviewed, which suggested some small changes to make the recommendations steps in a protocol rather than a set of potential actions. Some requirements needed to be much firmer, like the need for regular Cal/Val of sensors. It needed better references of stray light and uncertainties to make the document more flexible.
- RadCalNet is a collection of individual test sites for their own SR measurements. The goal is to provide data in a common format into a processing chain that is common and operated and managed by NASA. Deliver TOA hyperspectral reflectances every 30 minutes for a nadir view. The tool is gradually increasing in users over its 6 years of operation. There are over 1000 registered users, and more than 500 of them are active.
- Collection 2024 released July 2024 (full reprocessing of archive) may be a potential story for promotion by the CEOS Communications team.
- Nigel acknowledged that we need to ensure the long term sustainability of sites. We agreed as a community not to charge users. Various organisations like Chile are keen to develop sites and are looking for help. Proposed a recommendation for consideration, noting the desire and importance of mainstream agencies and new space to have a common long term infrastructure and philosophy of continued support of these sites.
- Nigel asked if CEOS has the capacity to build a Working Group to provide resources to develop smaller agencies or regions where such sites may exist. There are lots of locations for good sites and keen people, but they don't quite know how or have the instrumentation.
- Regarding the FRM QA framework, presentations on Lessons learned from CaTSSITTR recognise that assessments can be subjective and pessimistic. We need to do something to reflect what is claimed in the description, that should be built into the project's development cycle at an early stage.

- PICSCAR is an initiative that ensures methods for using PICS are consistent, coherent, and differences are understood. The initiative was set up looking at how different agencies use a site, and how they compare Landsat-8 and Sentinel-2 for their own methods. The variance between methods has started to reduce. We want to evolve the process to other sites beyond Libya 4, at least to 6 CEOS priority sites.
- All different sites are stable. We decided that before we release community data, there is work to be done on improving the BRDF model using the latest Parasol data. A review meeting with GSICS will be held to consolidate activities.
- Drones used for water quality validation chimes well with SRIX4Veg, and shows additional challenges that water bodies present. The philosophy is that drones could bring broader coverage than ship sounding to validate observations from sensors like Sentinel-2. We need to work towards FRM and have a protocol. Do we need something like LPV for water, and where does it sit within CEOS? If not, who takes responsibility for protocols for water bodies and oceans? This may be an *ad hoc* activity.
- IVOS reviewed how MODIS and VIIRS are using the moon as a reference to identify biases. They looked at the stability of OLCI as well as EnMAP and how it has improved from SWIR degradation. The performance of OLCI-A and Air-Lusi was compared against LIME. It is early days as a comparison activity, but it speculatively implies that Air-Lusi and OLCI-A agree consistently with 5% bias in the LIME model of those 2 sensors.
- The CEOS solar spectral irradiance spectrum is starting to be used in real earnest. Reprocessing of Sentinel-2 OLCI and the difference in the L1 product (no change to L2) is underway, and sensor comparisons like how MODIS and VIIRS data compares to what it would be if they used TSIS. These are starting to be adopted and needs to be promoted to New space.
- There was not much New space participation at IVOS.
- We might need to do comparisons of functionality of the radiative transfer codes at the sub 1% level. RADIATE is funded by ESA and the EU.
- Uncertainty, traceability and QA, are in particular focus to progress further. Cody organised at JACIE a half-day workshop on uncertainty as a largely educational purpose and to start dialogue. IVOS have started to scope the minimum requirements from New Space that are useful for us in terms of QA. If we're going to require them to do this, we need the evidence to say why it's necessary. So we need to do sensitivity studies. It's a growing activity within IVOS, and will continue to get more information to develop a 'buyer's handbook' for government agencies buying New Space data.
- TIRCalNet is effectively a mirror of RadCalNet but focused on TIR, providing TOA brightness temperature for medium to high resolution sensors, focused with a particular objective to reach half a Kelvin with TOA propagated from BOA. There are various tasks set up to achieve these goals, and discussions to be had on uncertainty budgets. There are some concerns that emissivity seemed to be the biggest driver when looking at uncertainty budgets, especially over water.
- Evaluations imply consistency at the 1/10th kelvin level between sensors. Process is going well, starting to get the harmonious way of developing a protocol and methodology.

- It would be timely to start thinking of an operational network in the current time frame when developing the protocols. The earlier you think of a network, the easier it is to develop structures and protocol coherence.

Discussion

- Peter Strobl (EC-JRC) noted that we are aiming within a 5-10 years time frame. Like with elevation models, it's a moving frontier, and there's still a lot of money to be made in high precision.
- IVOS is trying to solicit who's interested to work on these activities. Cody considered also including national datasets. Harder locations in the world are usually held by the DoD, and even getting a coarse version of data is tough.
- We need to consider if we have done enough that is appropriate for CEOS to coordinate. Give a potential list of items for agencies to decide whether they want to pursue a coordinated activity in a particular area. A strawman for agencies wanting to join discussions.
- Philippe Goryl (ESA, WGCV Chair) noted that these activities are everywhere, and coordination with these Cal/Val parks would be good. Nigel added that we are at the stage of who wants to join, and what are the priority activities. We don't have a champion yet.
- Regarding Nigel's comment on drones for water quality, Philippe noted that Vito can do the work but it needs a stamp. Cody recalled the CEOS-ARD PFS for Aquatic Reflectance. Kurt added that some of those activities are the result of breaks between WGCV and the ocean community because they do their Cal/Val activities differently. It doesn't fit within Virtual Constellations because it's Cal/Val.
- Michael Cosh (USDA) noted that from LPV, there are various water components like inundation and reservoirs. SWOT products may fit with some work. Not sure if it's being captured.
- Peter Strobl added that this is one reason to think of robust categorisation. We need to draw the line and if we don't, there are spillovers or things being done twice. CEOS will have to organise how it wants to cut its cake. Philippe noted that COAST-VC should rely on WGCV for all aspects of Cal/Val. The stamp can and should be WGCV.
- Cody Anderson (USGS, WGCV Vice Chair) noted that if it is a WGCV stamp, we'd have to consider SRIX4Veg and whether the protocols are consistent. There are probably changes to be made to make it coherent with the others. Peter recalled the same issues with ARD.
- Regarding Nigel's slide on the solar spectral irradiance evolutions, Philippe suggested having a table of missions with examples onto the Cal/Val portal.
- Nigel proposed an SEO story to communicate this.

WGCV-54-15	Nigel Fox and Paolo Castracane to collate IVOS achievements (e.g., the solar spectral irradiance spectrum work) on the Cal/Val Portal and communicate them to the CEOS Communications team for promotion.	WGCV-55
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- Regarding Nigel’s emissivity concern, Kurt noted that for the Lake Tahoe case, most people would not use the same range of emissivity as they would for La Crau.
- Nigel added that measurements show consistency with MODIS over land. One is concerned that the spread of data is worse over lake Tahoe as it is over land. Work is in progress that needs to be thought of in TIRCalNet.
- Philippe suggested that TIRCalNet has a roadmap. The output and progress is there, but there’s nothing in the roadmap about developing a network.
- Peter suggested that the volunteer for leadership of image quality geometric should be the same person that helps TMSG with GCPix.
- David Deolling was happy using the TSIS 1 solar irradiance spectrum and using PICS sites from the GSICS perspective, and asked if there is any way they can have a web meeting?
- The priority is for Nigel to talk to GSICS to organise a joint meeting. Patrice Henry leads PICSCAR, and the website is available through the Cal/Val portal. The effort from these initiatives needs to be efficient, and WGCV is keen to be linked to what GSICS are doing.

WGCV-54-16	Paolo Castracane to coordinate with Patrice Henry and Beatrice Berthelot to present PICSCAR in one of the regular GSICS VIS/NIR teleconferences.	TBC
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- David is trying to get users of a common framework with the DIMITRI dataset and would like a demonstration of how the tool works.
- The ESA lead is Marc Bouvet who also leads RadCalNet.
- Paolo Castracane (ESA) suggested an update to the IVOS radiometric database.

WGCV-54-17	Beatrice Berthelot and Marc Bouvet to present DIMITRI / VICALOPS in one of the regular GSICS VIS/NIR teleconferences.	TBC
WGCV-54-18	Paolo Castracane to work with Nigel Fox to establish on the Cal/Val Portal an IVOS database on radiometric calibration capabilities.	WGCV-55

3.5 - GSICS Collaboration update

Paolo Castracane (ESA) reported [\[slides\]](#):

- The GSICS annual meeting was held from 11-15 March 2024 at EUMETSAT HQ, Darmstadt, Germany.
- Actions taken include communication and coordination for the SITSat Task Team. The Cal/Val portal and GSICS both have dedicated pages for SITSats. There is an action to reduce overlap and avoid duplication of information between the Cal/Val portal and GSICS sites.

- The SITSat Task Team site on the Cal/Val portal has a forum and repository, and the GSICS page shows key information of SI-traceable missions.
- The pre-flight calibration workshop organising and scientific committees have representation from both CEOS WGCV and WMO GSICS.
- Areas of cooperation: Both WGCV and GSICS have subgroups that are in cases very similar, so it's important to have collaboration. On the topic of new space, there are common initiatives for participation in VH-RODA in 2024 and JACIE in 2025. Regarding maturity matrix cooperation, GSICS are working on a product acceptance workflow derived from the QA4EO framework.
- Outreach includes Cal/Val portal sharing links to GSICS tools, conferences, workshops and projects. There is a CEOS WGCV X site, as well as the GSICS Wiki page.
- Manik Bali (GSICS) added that the collaboration spans different levels. The microwave groups overlap in goals for calibration, and GSICS face an exciting year ahead for collaboration.

Discussion

- Philippe Goryl (ESA, WGCV Chair) noted that we should reinforce collaboration with IVOS for vicarious calibration and PICS in general, as it's a big area of collaboration. The microwave domain is very active so there are activities in Cal/Val where coordination is needed. Presentations during regular teleconferences to present PICSCAR and DIMITRI would be good.
- Paolo noted that in the past there have been monthly GSICS telecons.
- Manik Bali (WMO GSICS) asked for guidance from the SITSat Task Team on what they expect from GSICS, and where they can complement the task team. Yolanda and Nigel asked for help wherever they can, and welcome any suggestions for the development of the new SITSat website.
- Philippe would like to see something in the format of Rayleigh processing.

3.6 - Synthetic Aperture Radar (SAR) Subgroup Report

Stéphane Côté (CSA) reported on the SAR Subgroup:

[slides: [SAR Subgroup Report](#), [SARCalNet](#)]

- Dirk Geudtner (SAR Subgroup Chair) is currently engaged with IAC so Stephane presented in the chair's absence. This session intends to follow up on WGCV-53 actions including the interest of altimetry in WCGV.
- The SAR subgroup workshop will be held in Ahmedabad, India from November 12-15, hosted by ISRO, with an expected attendance of ~150. The workshop has 70 abstracts submitted, and includes a poster session. All authors were sent acceptance emails, and the programme is being finalised. Stephane welcomed anyone else interested in joining.
- The programme is a blend of topics such as Cal/Val for operational and future missions, Cal/Val infrastructure, ARD, InSAR, emerging subjects like AI for Cal/Val, systems monitoring, and parameters for geophysical applications like sea surface and crop classification.

- The subgroup will report at the next WGCV the details and summaries on work developments, discussions, and actions from this workshop.
- WGCV-53-ACT-04 on DEM mission continuity regards underlining the importance of funding missions like TanDEM-X. A point was added to the CEOS Plenary WGCV Chair Report, as a result of Dirk's communication with DLR.
- WGCV-53-ACT-15 on the altimetry representation in WGCV has been addressed by including altimetry Cal/Val as a topic in the SAR workshop, to which a couple contributions have been submitted. This action was closed, but it could be kept open, as it is incarnated through InSAR altimetry and within the subgroup. The topic will be presented at the workshop, but there could be an outreach dimension to this action.
- Philippe pointed out that altimetry was absent from WGCV, and they have their own community and Cal/Val. So there is no need to duplicate their work. A reporting of what is happening in the altimetry community and SAR subgroup. SAR is the closest to the altimetry community.
- Altimetry can also fit within MSSG, so we could coordinate this action. Xiaolong Dong presented high wind measurements from Sentinel-1 SAR. Coordination here between the two subgroups should be encouraged.

Bruce Chapman (JPL) reported on SARCALNET:

- Work has been done on making target calibration sites more useful to the community, including the addition of the SARCalNet handbook. In order to facilitate SARCalNet, important criteria are required to make it easy for people to submit detailed and complete information. Submissions to SARCalNet are done through submission templates that the owner of a calibration site would complete and submit to the SARCalNet website team. Future plans include software calibration tools, and information on SAR data providers and how their datasets can be obtained. Submission templates are available on the SARCALNET website.
- Trihedral corner reflectors used for geometric calibration. The distributed targets are large natural targets commonly used in calibrating imagery.
- SARCalNet users wanted their targets to be included in the CEOS point target database, but submissions were not updated frequently enough. The ultimate objective is to have joint calibration and target sites to directly compare calibration results over the same sites.
- Users need guidance in defining the target positions and orientations. Templates are completed by those supporting Cal/Val sites, which are ingested into the database by the SARCalNet website team. The self assessment form also prompts the user of any restrictions of the information in its distribution to the public. After ingestion, it is published on the website labelled 'under review' until it is endorsed.
- The interface currently has two entries, which will be reviewed at the meeting in November.
- Once you have picked a calibration target you're interested in imaging with your SAR, the interface shows more information about the site and the user can download a survey.

- The team is interested in supporting a GitHub location that would have software for imagery calibration.
- Future additions to SARCalNet include information on auxiliary data sources commonly used to perform calibration activities (such as DTMs and ionospheric and tropospheric datasets), as well as heritage missions.
- Several documents are close to completion, which will hopefully be online before the end of the calendar year.
- The subgroup wants to facilitate the discovery of open source Cal/Val tools for data analysis, and are working on putting that together.

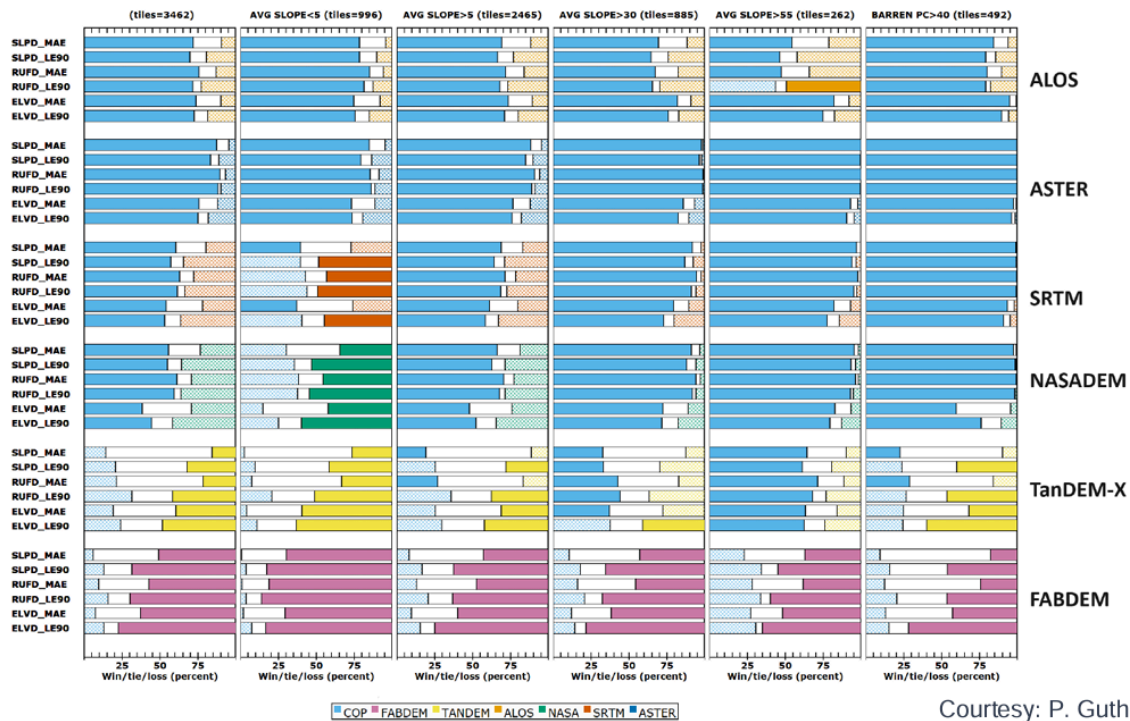
Discussion

- Philippe Goryl (ESA, WGCV Chair) noted that Eric Laliberte (CEOS Chair) sent an email last week to CEOS principals, and had a discussion at a recent SIT meeting about the international coordination group for SAR, and the potential overlap with WGCV on Cal/Val. Is this coordination happening? The group was made in 2018, so was sceptical of what is happening.
- Bruce was leading Cal/Val discussions for the international SAR coordination group and reported what the CEOS Cal/Val group was doing, making sure they were well informed of what might be required for Cal/Val for future missions. However the differences between the two groups has been hard to define.
- Those most involved in the coordination group were aware that CEOS does the same type of activities, and want to be involved and integrated with CEOS. The International SAR coord group meeting will be in Tokyo, Japan, although Bruce cannot attend. It would be nice to have some representatives from WGCV or CEOS.
- Stephane noted that the RCM mission manager will attend, and will try to communicate with Eric to develop a strategy for articulation between the two groups. The objectives of the coordination group have been wide, so we need to further clarify how the SAR subgroup can contribute.
- Medhavy Thankappan (GA) noted that this group has a broader coordination for missions and campaigns. Perhaps a SAR Virtual Constellation. The distinction between the two groups should be clarified.
- Jonathan Hodge (SEO) commented in response to discussions around CEOS CAL providing data over SARCalNet sites. It would be great to get for first sites polygons or point locations, so data can be processed from various platforms into CAL. Jonathan is also working with commercial providers to assess the compatibility of their data.
- Bruce had discussions with commercial SAR satellites operators, who often use reflectors designed not for X-band but L- and C-band. Bruce is interested in hearing and supporting their data calibration. It's important to have access to these calibration datasets to evaluate the targets.

3.7 - Terrain Mapping Subgroup (TMSG) Report

Peter Strobl (TMSG Chair, EC) reported [\[slides\]](#):

- TMSG is operating in its sixth year. The subgroup had a virtual Plenary last week with 20 participants.
- The DEMIX (Digital Elevation Model Inter-comparison eXercise) team has progressed for four years, attending three plenaries and fortnightly meetings, and producing four peer reviewed publications, a new DEMIX tiling system, and a processing platform. They are currently working on a comprehensive final report.
- The paper on DEM terminology and definitions has received a lot of citations.
- The DEMIX wine contest serves as a process for benchmarking data. Usually one would never resample DEMs, but try to get reference data to aggregate to their data which has a lower uncertainty than the data themselves. As soon as you resample you falsify results.
- There is no agreement across the most common global DEMs on how to grid. The first round of the DEMIX test had 24 test areas and 236 tiles 10 square kilometres in area. Data was classified primarily through three classes: elevation, slope, and roughness.
- COPDEM was the overall best DSM, and FABDEM is the best DTM.
- Low-elevation coastal areas were sampled across the US and Europe. New parameters were explored such as river networks and channels, and how they match between reference and candidates.
- The fit was explored through the fraction of unexplained variance. DEMs are generally good in representing elevation. 90% have explained 90% of the variance in the terrain model. Sub-ten metre elevations experience more noise issues.
- A new way of visualising comparisons between DEM pairs performance against reference DTMs can provide confirmation of 'wine contest' findings. They highlight that in some areas products have strengths and that they can be utilised in these settings.



- If you compare copernicus against the others, you'll see that the picture is pretty consistent.
- As soon as you start modifying a DEM, you might get the elevation adjusted, but you might ruin a lot of the secondary information.
- Hallucinating DTMs occur when you let a sophisticated algorithm correct the DEM and it can sometimes start to fabricate information. Barren areas will show different DSM and DTMs despite them being almost the same in reality. Only small settlements should make the difference between the two.
- Peter asked again for someone new to join the team as co-chair.

Discussion

- Nigel Fox (NPL) asked if by global grids, Peter referred to community reporting grids. Peter confirmed, and noted that in the future we cannot afford to have tilings not nested with the actual reading underneath.
- Philippe Goryl (ESA, WGCV Chair) pointed out that our ARD requirements are on geometry and not grids.
- Cody Anderson (USGS, WGCV Vice Chair) noted that the commercial sector is going after 1m pixel sizes, where getting 1/10th pixel accuracy is impossible. We need to raise awareness that we don't have a focal point for this discussion. WGISS should be involved if we want to bring other agencies into this discussion.

- Jean-Christopher Lambert (IASB-BIRA) noted that the EU INSPIRE directive has technical specifications for the grids for common origin points. However it's not extendable, so not worth mentioning at global scale.
- Greg Stensaas (USGS) suggested we have the discussion within TMSG and encourage WGISS participation.
- Peter will send around a survey asking them a few questions on what they'd like to engage in.
- The priority should be on GCPIX. More ambitious would be a way to validate or calibrate at higher resolution, reaching co-registration at sub metre resolution.
- Medhavy noted relevance to LSI-VC, in which people often ask why the PFSs don't cater to higher resolution datasets. Peter responded that one reason we cannot request they hold to ½ pixel registration is that there is no reference data.
- There are many effects to consider when coregistering spectral bands at high resolution. One can easily get into questions that are far from terrain mapping. Coregistering at the level of buildings with effects that might come from focal planes and overflight times, angular distortions, parallax.
- Greg noted that a lot of discussions are happening in the high resolution realm in making digital twins ect.
- The next TMSG meeting will be at Geomorphology 2025 in June 2025 at Perugia, Italy.

3.8 - ACIX-III, CMIX-II and Cloud Camera Network

Philippe Goryl (ESA, WGCV Chair) reported in absence of Eric Vermote:

- ACIX is co-managed by ESA and NASA. ACIX-III tried to give direction to hyperspectral sensors like PRISMA (Italy) and EnMAP (DLR). A workshop is planned in March 2025 in Paris.
- The NASA and ESA teams are working together, with Ferran Gascon on the ESA side, and David Thompson JPL.
- CMIX-II is going well too, but faces more difficulties. Initially, we wanted to see what was happening in the hyperspectral realm, but there was little participation. The new focus is on multispectral Landsat and Sentinel. Results are expected by 2025.

ACIX/CMIX: Optical Imaging Intercomparison Exercises



- Intercomparison Exercises in the optical domain: ACIX (Land/Aqua) and CMIX
- The coordination of the exercises lies with the NASA and ESA
- A joint session is proposed at ESA Living Planet Symposium in June 2025 in Vienna to present and discuss current activities and latest results

Atmospheric Correction Intercomparison eXercise (ACIX)

- Intercomparison of atmospheric correction algorithms for surface reflectance, aerosol and water vapour retrieval jointly organized by **ESA and NASA within the frame of CEOS WGCV, with coordination by CNR for ACIX Aqua**
- Dedicated activities for scenes over land and those over water from the second implementation
- 8 years of activities, with ACIX (2016 – 2018) and ACIX-II Land/ACIX-II Aqua (2018 – 2021) using Landsat and Sentinel-2 imagery

Current implementations:

- ACIX-III Land (2021-):** Atmospheric correction algorithms over land scenes with imaging spectroscopy data
- Inclusion of 100 scenes from PRISMA and EnMAP satellites
 - Reference data from RadCalNet, HYPERNETS, AERONET and ad-hoc validation campaigns
 - Participant results submitted in August 2024
 - Results workshop planned for March 2025

- ACIX-III Aqua (2021-):** Atmospheric correction algorithms over water scenes with imaging spectroscopy data
- Inclusion of PRISMA scenes, 239 scenes over 26 inland and coastal water sites
 - Reference data from AERONET-OC and hyperspectral stations: WISPSatStations, LoExplore, HYPERNETS and ad-hoc field campaigns
 - Participant results submitted in 2024, analysis of results on-going

Cloud Masking Intercomparison eXercise (CMIX)

- Intercomparison cloud masking algorithms jointly organized by **ESA and NASA within the frame of CEOS WGCV**
- Cloud masking was included in the first ACIX implementation ACIX (2016 – 2018) and has been run as a separated CMIX activity (first implementation 2018 – 2021) using Landsat and Sentinel-2 imagery
- Inclusion of both physical and machine-learning based algorithms

Current implementation:

- CMIX-II (2021-):** Intercomparison of cloud masking algorithms on multispectral data

- Inclusion of Landsat-8 and Sentinel-2 scenes
- Test run with participants has been completed
- Variety of validation datasets:
 - PixBox – expert pixel collection including COD for Sentinel-2 and Landsat
 - Sky camera-based reference dataset including COD developed by NASA/UMD
 - Multi-temporal dataset
 - Collaborative dataset using IRIS tool from ESA Phi-Lab
- Results expected 2025

Future implementation:

- CMIX-III** with focus on imaging spectroscopy (PRISMA, EnMAP, ...)?

Participating algorithms							
ACIX-III Land		ACIX-III Aqua		CMIX-II			
acoliteidsf	hyper-siac	acoliteidsf	acolite-l-rnar1	cd4cm	kappa-mask	paco	
otrem	imeacor	icor	polymer	force	magcma	sensei	
geonex-ac	isoft	hgrs	prisma l2c	hikeriu	mea	siac	
hikeriu	magac	mp		idepoc	overland	senzcor	

- The optical domain is doing a lot on atmospheric corrections. One difficult thing is cloud masking. We need to continue to develop this exercise and understand from the community what we want in terms of cloud masking.
- Would like a CMIX-III sometime but hyperspectral.

3.9 - WGCV support to other initiatives

Philippe Goryl (ESA, WGCV Chair) reported [slides]:

- Philippe’s vision for WGCV saw support to initiatives including:
 - Climate with GCOS IP
 - Contribution to the GHG Roadmap
 - Participation and contribution to WMO’s 1st CIPM STG-CENV CIPM
 - Continued support to biodiversity
 - Coordination with WMO GSCIS
 - Further cooperation with CEOS Working Groups like WGISS on joint topics (e.g. interoperability)
 - New Space support
- CEOS WGCV’s recommendation for member agencies and commercial providers to regularly share imagery for quality assessment against a common ‘CEOS reference’, accessible by API or a dedicated CEOS archive.

- WGCV should support methods, protocols, tools, and expertise, with support to agencies, New space, thematic groups on climate, biodiversity, ect. Continued support to providing FRMs e.g. from RadCalNet, SARCalNet, TIRCalNet, and PICS, with a major goal toward producing FRMs from space with SITSats.
- For metrology for climate action a workshop was held two years ago, which compiled a list of recommendations. A lot were relevant for WGCV and we were likely the most relevant body to the workshop. Atmospheric is one of the most discussed domains. There was a recommendation to increase confidence in data and make it fit for purpose. We have an activity on the development of maturity matrices presented on day 1 relevant to this. BIRA-IASB (Jean-Christopher’s affiliation) presented as well, and is organising a dedicated session at LPS 2025 on metrology for climate action.
- WGCV was asked by WGClimate to give inputs to the GCOS implementation plan. Four topics relevant for WGCV and vice versa.
 - B1.3 Better align the satellite FRM program to the reference tier of tiered networks and enhance/expand FRM to fill gaps in satellite cal/val.
 - B5.1 Increase the number of in situ river level observations that are exchanged internationally and can be used to calibrate satellite observations of water levels.
 - D4. Create a facility to access co-located in situ cal/val observations and satellite data for quality assurance of satellite products.
 - B 1. 5. Establish a long-term space-based reference calibration system to enhance the quality and traceability of earth observations. The following measurables are to be considered: high-resolution spectral radiances in the reflected solar (RS) and infrared (IR) wave bands, as well as GNSS radio occultations.
- Philippe has responded to the actions with the help of Matt Steventon (Symbios).
- The last one was interesting. In reality, we have the matchup databases or *in situ* databases for radiometry. If we try to put everything into one bundle then it’s a lot to consider and complicated to communicate.
- Biodiversity is the CEOS Chair (CSA) priority, so it’s important to explore how we can support it. From the last WGCV meeting we decided to support the EBVs, starting from the one already addressed - the development of quality standards.
- FRM4LC (land cover); in terms of biodiversity, land cover is the fundamental parameter, and we’re keen to see what it means. In Paris, there was a presentation at NPL toward FRM4LC, noting that initial progress is underway.
- By essence, WGCV is providing support well to other groups. How this support is recognised and how we maintain coordination is important. We need to formalise our support and make sure our inputs are indeed useful.
- We are often asked for radiometric accuracies, and we can’t give a definite answer. SITSat observations will help us unearth these.

Discussion

- Jean-Christopher Lambert (IASB-BIRA) noted that climate change related visibility in the atmospheric domain is dominated by topics related to CO₂ and CH₄. These molecules are obviously of prime interest but they are not the only ones, there are a lot of interesting activities around N₂O, aerosols, ozone, NO₂, HCHO, NH₃, CO and SO₂. All of those are GCOS ECVs (or ECV precursors), and some are Kyoto greenhouse gases for which emissions are regulated by the Paris Agreement, N₂O and SF₆ being two of them. The prime interest on CO₂ and CH₄ is sometimes a detriment to the development of e.g. FRM activities for the other molecules. Taking the CCI programme as an example, the current quality of ground-based measurements data records needed to validate long term satellite-based Climate Data Records of several ECV precursors (tropospheric HCHO, SO₂, CHOCHO...) is really limited and deserves specific effort. Another issue is sometimes identifying suitable quality/uncertainty requirements for the FRMs and related validation activities. Satellite NO₂/HCHO/SO₂ requirements from the GCOS Implementation Plan are not intended to represent all communities of users.
- Philippe noted that we should define some quality requirements, and emphasise the need to work on other ECVs.
- Nigel Fox (NPL) saw the challenge to present WGCV's support to other initiatives in ten minutes, and maybe that slideset should be recorded as a video so it can be distributed to youtube as an advert for what we do. Something easily distributed and on the web that easily says what we do.
- Nigel noted that we need a set of simple stories to communicate what WGCV does. Kurt added that the GSICS example is a good one. A well focused idea and group. Did what they wanted to do and then made it available to a broader community. The subgroups do well in our niches, but as an umbrella we struggle to distil it down to a couple key areas.
- Kurt Thome (NASA) noted that WGCV is the closest to GSICS in what we do. RadCalNet did well because it fed from IVOS, and there was enough energy at the WGCV level to get ESA and NASA support which then filtered in NPL. Now it's viewed as a modest success.
- Cody Anderson (USGS, WGCV Vice Chair) noted that whenever ARD or interoperability comes up, it always comes to things like that Landsat or Sentinel aren't married up gridding and projection-wise. If we can't do that ourselves, why should anyone listen to us?
- Kurt pointed out that ACSG has the best examples WGCV could latch onto; examples that are more straightforward. There's also a virtual constellation we can directly link into.
- Akihiko Kuze (JAXA) noted that climate sensors are still challenging. OCO-2 and 3 use the same parts, but CO₂ measurements between them still have biases. We need auxiliary information like wind speed. Now we more and more understand that Cal/Val is important.
- Philippe suggested a high level action for the next WGCV meeting, with an initial focus on something readily justifiable like the atmospheric domain.

	develop a WGCV Communication strategy, including the potential production of a video to promote WGCV capabilities.	
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3.10 - Review of Day 3 Actions

Harvey Jones (WGCV Secretariat) reported:

- All new WGCV-54 actions were reviewed, refined, and confirmed.

Discussion

- (former) Action-13 on the Post-2025 GEO Work Programme. We’re not going to operations, just going live. The action was deleted.
- Philippe Goryl (ESA, WGCV Chair) suggested an overview of all missions that use the TSIS solar irradiance spectrum.
- Nigel Fox (NPL) noted that it’s not an easy task. IVOS intended to highlight, with examples, missions that have switched the TSIS spectrum and evidence that working.
- Kurt Thome (NASA) would be more happy to have a strong statement to say that all operational systems should make clear what solar irradiance spectrum they are using. Philippe suggested raising this at Plenary. Cody added that DLR has a proprietary spectrum so won’t be happy.

WGCV-54-20	Cody to hold a discussion on the demonstration of the impact of WGCV on specific applications / virtual constellations (CF GSICS)	WGCV-55
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Appendix A: List of Participants

In-person participants

Affiliation	Name
CEOS Executive Officer	Steven Ramage
ESA	Philippe Goryl
ESA	Paolo Castracane
EC-JRC	Peter Strobl
GISTDA	Prayot Puangjaktha
GA	Medhavy Thankappan
IASB-BIRA	Jean-Christopher Lambert
JAXA	Akihiko Kuze
JAXA	Kazuhisa Tanada
NASA	Yolanda Shea
NASA	Kurt Thome
NOAA	Slawomir Blonski
NPL	Nigel Fox
USDA	Michael Cosh
USGS	Cody Anderson
USGS	Gregory Stensaas
WGCV Secretariat	Harvey Jones

Virtual Participants

Affiliation	Name
CSA	Stephane Cote
CSIRO	Ian Christopher Lau
ESA	Valentina Boccia
ESA	Sabrina Pinori
GA	Simon Oliver
NASA	Bruce Chapman
NOAA	Larry Flynn
MYSA	Adhwa Bin Amir Tan
MYSA	Wayne Ng Su Wai
NSSC	Xiaolong Dong
NOAA	Lawrence Flynn
WGCV Secretariat	Matt Steventon
WMO GSICS	Manik Bali

Appendix B: Decisions

Decision 01	WGCV endorsed the nomination of Medhavy Thankappan of Geoscience Australia as Vice Chair of the WGCV for two years (2025-2026), followed by WGCV Chair for two years (2027-2028).
Decision 02	WGCV endorsed the <i>Good Practice Guidelines for UAV-based Surface Reflectance Validation</i> , subject to the implementation of final minor modifications proposed by the IVOS Subgroup (largely structural and not impacting the overall principle of the document).
Decision 03	WGCV endorsed the <i>Best Practice Protocol For The Validation Of Aerosol, Cloud, And Precipitation Profiles</i> .

Appendix C: Actions

WGCV-54-01	<p>In support of the SITSat Task Team’s communication strategy, WGCV members are asked to help gather examples/case studies regarding ‘real world’ impacts of the reduction in uncertainties that are facilitated by SITSats.</p> <p>We seek to show the unique value of these types of missions and highlight differences between usual calibration practices and those provided by SITSats. Examples should be accompanied by clear, transparent metrics (financial, improved decision-making, etc.).</p>	June 2025
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	These examples will be presented at a dedicated session at the Living Planet Symposium in June 2025.	
WGCV-54-02	WGCV members are asked to identify for priority target missions of SITSats a list of their products and associated uncertainties.	June 2025
WGCV-54-03	Peter Strobl to connect with the COAST-VC leads to explore the application of DEMIX for low elevations, as well as the idea of creating/testing a global coastal elevation dataset/method.	WGCV-55
WGCV-54-04	MSSG Chair and WGCV Chair to coordinate a discussion on the relevance of the FRM concept and explore the potential for a contribution to the Assessment Framework activities.	WGCV-55
WGCV-54-05	Paolo and Nigel to make updates to the FRM Assessment Framework documentation to: <ul style="list-style-type: none"> ● Make clear that the assessment is relative to the intended purpose of the site. ● Remove subjectivity in parameters by incorporating clarifications present in the accompanying documentation, but which have to date been left out of the Matrix description. ● Clarify that verification should be undertaken by independent people from CEOS, not the person filling in the template (i.e., self-assessment followed by independent review). ● Make the Validation column a different colour. ● Consider inclusion of additional links to reference materials, mechanisms to allow assessors to provide feedback, etc. 	Q4 2024
WGCV-54-06	Paolo, Nigel and Kuze-san, to work with Jean-Christopher Lambert on the issues with the FRM Assessment Framework specific to the atmospheric domain.	Q4 2024
WGCV-54-07	Philippe and Nigel to initiate a discussion with WMO representatives on key <i>in situ</i> networks that could be brought in line with the FRM Assessment Framework / labelling. We would like to see broad utilisation of the FRM label.	WGCV-55
WGCV-54-08	Paolo and Jean-Christopher to update the CEOS Cal/Val Portal with details of recent activities of the Atmospheric Composition Subgroup (ACSG).	Q4 2024
WGCV-54-09	Medhavy Thankappan, Simon Oliver, and Cody Anderson to prepare some questions specifically for LPV, IVOS, and LSI-VC regarding the Surface Reflectance Consistency project and	Q4 2024

	<p>organise a follow up discussion with these groups, including the potential formation of an <i>ad hoc</i> group under WGCV.</p> <p>Philippe Goryl to raise at the next CEOS Secretariat meeting at CEOS Plenary 2024.</p>	
WGCV-54-10	MSSG Chair to communicate the subgroup's latest activities, in particular the GNSS-RO team and their work, to gauge WGCV participation interest.	Q4 2024
WGCV-54-11	Paolo Castracane to work with MSSG to update the subgroup's Cal/Val Portal page.	Q2 2025
WGCV-54-12	Paolo Castracane to organise a second FRM Assessment Framework exercise to include PGN, FRM4DOAS, and RadCalNet as a minimum. Updates will be reported at WGCV-55.	1 June 2025
WGCV-54-13	WGCV to confirm the readiness of operationalisation and conduct a pre-launch review of the FRM Assessment Framework, and to define candidates for operational usage e.g. HYPERNETS.	WGCV-55
WGCV-54-14	Medhavy Thankappan to work with subgroup chairs to review the Terms of Reference from the RadCalNet CEOS WGCV review panel and identify suitable evaluators of the different types of submissions to the FRM Assessment Framework.	January 2025
WGCV-54-15	Nigel Fox and Paolo Castracane to collate IVOS achievements (e.g., the solar spectral irradiance spectrum work) on the Cal/Val Portal and communicate them to the CEOS Communications team for promotion.	WGCV-55
WGCV-54-16	Paolo Castracane to coordinate with Patrice Henry and Beatrice Berthelot to present PICSCAR in one of the regular GSICS VIS/NIR teleconferences.	WGCV-55
WGCV-54-17	Beatrice Berthelot and Marc Bouvet to present DIMITRI / VICALOPS in one of the regular GSICS VIS/NIR teleconferences.	WGCV-55
WGCV-54-18	Paolo Castracane to work with Nigel Fox to establish on the Cal/Val Portal an IVOS database on radiometric calibration capabilities.	WGCV-55
WGCV-54-19	WGCV Chair to work with CEOS Communications Team to develop a WGCV Communication strategy, including the potential production of a video to promote WGCV capabilities.	WGCV-55
WGCV-54-20	Cody to hold a discussion on the demonstration of the impact	WGCV-55

	of WGCV on specific applications / virtual constellations (CF GSICS)	
WGCV-54-21	LPV Chair to coordinate a review of the Land Cover and Change Map Accuracy Assessment and Area Estimation Good Practices Protocol within WGCV, for endorsement at WGCV-55.	WGCV-55